Answers to Review Questions:

Chapter 1
Q1.1 (b)
Q1.2 (c)
Q1.3 (c)
Q1.4 (d)
Q1.5 (c)

Chapter 2
Q2.1 (d)
Q2.2 (c)
Q2.3 (a)
Q2.4 (b)
Q2.5 (a)

Chapter 3
Q3.1 (c)
Q3.2 (c)
Q3.3 (b)
Q3.4 (a)

Chapter 4
Q4.1 (b)
Q4.2 (c)
Q4.3 (c)
Q4.4 (b)
Q4.5 (d)

Chapter 5
Q5.1 (b)
Q5.2 (c)
Q5.3 (c)
Q5.4 (a)
Q5.5 (d)

Chapter 6
Q6.1 (d)
Q6.2 (c)
Q6.3 (c)
Q6.4 (d)

Chapter 7
Q7.1 (c)
Q7.2 (a)
Q7.3 (b)

Q7.4 (d)
Q7.5 (d)

Answers to Problems:

Chapter 1

P1.1 The equivalent circuit reduces to the generator with two series 50 Ω loads, since the reactive parts are conjugate and therefore cancel. A simple voltage divider calculation gives the generator voltage as 6.32 mV (rms).

P1.2 There are two main beam lobes, ocurring at θ = 90°, and ϕ = 90° or 270° (the lobes are along each side of the *y*-axis). The beamwidth in both planes is 90°. The directivity can be found using equation (1.8), and is 4.8 dB.

P1.3 The main beam occurs at θ = 90°. The directivity is twice the directivity of a short dipole, or 4.8 dB.

P1.4 Using equation (1.9) gives the directivity as 41.6 dB.

P1.5 Use equation (1.10) to calculate the efficiency as 97%.

P1.6 First find the directivity as 1111 (numerical value), then use equation (1.9) to find the beamwidths as 5.4°.

P1.7 Let $E_x = 1$, and $E_y = 0.891$ (-1 dB down). Then use equation (1.14) to get an axial ratio of 1 dB.

Chapter 2

P2.1 This is actually a calculation of directivity using equation (1.8). The ϕ integration (from 0 to 2π) gives a factor of 2π. The θ integration runs from 0 to 12°, and gives a factor of 0.0219. The directivity is then 19.6 dB

P2.2 Using the Friis equation of (2.4) gives a range of 13.9 km.

P2.3 a) The polarization loss between a perfect CP antenna and a perfect linearly polarized antenna in any direction in 3 dB. b) The polarization loss factor between two oppositely polarized CP antennas is infinite.

P2.4 Use the radar equation of (2.7) to get a received power of -58.4 dBm.

Chapter 3

P3.1 Using the far-field approximation of equation (3.12) gives $R = 99.7500\ \lambda$ (for $z' = \lambda/2$) or $R = 100.2500\ \lambda$ (for $z' = -\lambda/2$). Using the law of cosines gives the exact values as $R = 99.75093\ \lambda$ or $R = 100.2509\ \lambda$. The error is about 9E-4 %.

P3.2 The expression for E_θ due to J_z in equation (3.16a) is seen to be the same as the corresponding expression in (3.15a), so the results will be the same.

P3.3 The pattern is $E_\theta = C \sin\theta$, the directivity is 1.8 dB, and the radiation resistance is the same as that given in equation (3.19) - which is one-fourth the value obtained for a small dipole having constant current.

P3.4 Starting with Joules law, and assuming that the current flows as a surface current on a good conductor, and the fact that $\bar{J}_s = \hat{z}I / 2\pi a$, we obtain

$$P_{loss} = \frac{\sigma}{2}\int_v \left|\bar{E}\right|^2 dv = \frac{R_s}{2}\int_s \left|\bar{J}_s\right|^2 ds = \frac{R_s}{4\pi a}\int_z \left|I(z)\right|^2 dz .$$

P3.5 The directivity is twice that of a small dipole, or 4.8 dB. The radiation resistance is one-half that of a small dipole.

P3.6 Using the formula that the power density at a distance r is, $S = \frac{P_t G_t}{4\pi r^2}$, gives a value of 0.0442 mW/m^2.

Chapter 4

P4.1 The element factor is the same as in Example 4.1, while the array factor has a cradiod shape pointing upward.

P4.2 Use the summation formula that $\sum_{n=1}^{N} x^{n-1} = \frac{1-x^N}{1-x}$, for $|x| < 1$.

P4.3 Beam maxima occur at $\theta = 90°$, 48°, and 132° (or -48°).

P4.4 Use PCAAD to plot the pattern.

P4.5 Using equation (4.8) gives the phase shift as -127°.

Chapter 5

P5.1 From (3.15), the far-zone field of the dipole is

$$E_\theta = \frac{j\omega\mu_0 I_0}{4\pi r} e^{-jkr} \sin\theta \int_{-L/2}^{L/2} \sin k\left(\frac{L}{2} - |z|\right) e^{jkz\cos\theta}$$

$$= \frac{ik\eta_0}{2\pi r} e^{-jkr} \sin\theta \int_{0}^{L/2} \sin k\left(\frac{L}{2} - z\right) \cos\left(kz\cos\theta\right) dz$$

which gives the desired result after evaluation of the integral.

P5.2 Using L'Hopital's rule on each expression gives the limit as zero for θ = 0.

P5.3 There is not a unique solution to this design problem, but one set of values that provides 11 dB gain at 860 MHz is: $N = 5$ elements (1 reflector, 1 fed element, 3 directors), reflector length = 16.64 cm, fed element length = 15.733 cm, director lengths = 15.42 cm, spacings = 8.72 cm, wire radius = 0.09 cm. The bandwidth for which the gain as at least 10 dB is 825 MHz to 889 MHz, or about 7%.

Chapter 6

P6.1 The first null in the pattern of (6.7a) occurs for

$$\frac{kb}{2}\sin\theta_n = \pm\pi \ ,$$

so $\sin\theta_n = \lambda / b$, which for $b >> \lambda$ reduces to $\theta_n = \lambda / b$ (in radians). Multiplying by two and converting to degrees gives equation (6.9).

P6.2 It is obvious from (6.15b) that the pattern is defined at θ = 0. Using L'Hopital's rule for $\frac{ka}{2}\sin\theta = \frac{\pi}{2}$ shows that the limit is non-zero.

P6.3 The first null for the pattern of (6.15b) occurs for

$$\frac{ka}{2}\sin\theta = \frac{3\pi}{2},$$

so $\sin\theta_n = \frac{3a}{2\lambda}$. For $a >> \lambda$ this simplifies to $\theta_n = \frac{3a}{2\lambda}$. Multiplying by two and converting to degrees gives $\theta_{nulls} = 172° \frac{\lambda}{a}$.

P6.4 From Table 6.1 the half-power beamwidth in the H-plane is 23°. PCAAD (linear array routine with one rectangular waveguide element) gives a value of 22°.

P6.5 The optimum feed pattern has $n = 6$, with a gain of 49.0 dB.

Chapter 7

P7.1 Either use PCAAD to get $L = W = 3.7$ cm, or the approximate formula that

$$L = W = \frac{c}{2f\sqrt{\varepsilon_r}} = 3.8 \text{ cm}.$$

P7.2 $L_1 = L_0\left(\frac{f_0}{f_1}\right) = 3.95\left(\frac{2.20}{2.45}\right) = 3.55 \text{ cm}.$

P7.3 Use the formula that $R(s) = R_0 \cos^2\left(\frac{\pi s}{L}\right)$ to get $s = 1.13$ cm.

P7.4 Use the approximate field expressions, or PCAAD, to get $W = 1$ cm.

Answers to Antenna IQ Test:

1. (d)
2. (c)
3. (c)
4. (d)
5. (d)
6. (b)
7. (c)
8. (c)
9. (a)
10. (a)
11. (b)
12. (c)
13. (d)
14. (c)
15. (b)
16. (d)
17. (b)
18. (c)
19. (c)
20. (c)
21. (a)
22. (b)
23. (d)
24. (d)
25. (b)