Learning Objective 2.5: I can explain the theory behind antenna pattern measurement, including anechoic chambers, near-field to far-field transformations, and standard gain horns.

Show your work. A **Documentation** line at the end is required (write **None** if you did not collaborate).

1. **Sizing the range.** A 0.75 m aperture antenna is to be pattern-tested at 8 GHz. Take $c = 3 \times 10^8$ m/s throughout.

   (a) Find the wavelength and the minimum far-field range length for this antenna.

   r_{ff} =

   (b) The only chamber available puts the source 12 m from the positioner. Find the edge phase error, in degrees, that this range imposes across the antenna.

   $\Delta\phi_{max}$ =

   (c) A colleague must test a 2.4 m reflector at 35 GHz. Find the far-field range length her measurement would require.

   r_{ff} =

   (d) Your colleague has no 1.3 km of chamber and no budget for a 1.3 km outdoor range. Name the two measurement approaches that solve her problem, and state in one sentence what each one trades away to do it.

2. **Reading a suspect pattern.** A short range does not fail obviously; it returns a pattern that still looks like a pattern.

   (a) In one or two sentences, explain physically why a source at finite range produces a phase error across the antenna under test that grows as the *square* of the distance from the aperture center.

   (b) An antenna with $D/\lambda = 25$ is measured at half its far-field distance. Find the edge phase error in degrees.

   $\Delta\phi_{max}$ = [ ]

   (c) In that same measurement the first null reads -16 dB instead of going deep, but the measured half-power beamwidth agrees with prediction to better than 2%. Explain, in one or two sentences, how both statements can be true at once.

   (d) A customer needs the -25 dB sidelobe of this antenna verified. Using the fact that a range at $2D^2/\lambda$ fills the first null to about -22 dB , at $5D^2/\lambda$ to about -30 dB , and at $10D^2/\lambda$ to about -36 dB , recommend a range length and defend it in one sentence.

3. **Specifying the chamber.** An anechoic chamber is not a room with no reflections. It is a room with reflections below a stated level.

   (a) Absorber reflectivity is quoted at normal incidence and degrades at grazing incidence. Explain why, and state which chamber surfaces this makes the critical ones.

   (b) A single stray reflection arrives 40 dB below the main beam. Find the worst-case error, in dB, that it adds to a measurement of (i) the main beam peak and (ii) a -30 dB sidelobe.

   main beam =

   sidelobe =

   (c) You must verify a -35 dB sidelobe to within ± 1 dB. Find the chamber reflectivity, relative to the main beam, that this requires.

   reflectivity =

   (d) Your antenna under test is 1.5 m across. The chamber datasheet advertises a 1.2 m quiet zone at -45 dB. State the problem in one sentence, and say what happens to the measurement if you proceed anyway.

4. **Two ways to an absolute number.** Pattern shape needs only a normalization; gain needs a calibration.

   (a) At 12 GHz a standard gain horn with a calibrated gain of 20.4 dBi receives -41.2 dBm . Swapping in the antenna under test, with nothing else touched, gives -29.8 dBm . Find the gain of the antenna under test.

   G_{AUT} = ____

   (b) The transmit power, the source antenna's gain, the range length, and the cable losses were all unknown in part (a), yet the answer is exact. Explain in one or two sentences why they do not matter.

   (c) No standard is available, so you set up two identical antennas facing each other at $R = 15$ m and 10 GHz. With $P_t = +10$ dBm you measure $P_r = -30.0$ dBm . Find the gain of one antenna.

   G = ____

   (d) Back in part (a): the standard gain horn is well matched, but the antenna under test has a VSWR of 2.0. Find the size of the resulting error, say which direction it pushes the answer, and state how you would report the result.

5. **Near-field scanning and the cut list.** The last two pieces of the midterm: how you measure when the range cannot exist, and what a complete characterization actually contains.

   (a) A near-field scanner must record both amplitude *and* phase at every sample point. Explain in one or two sentences why magnitude alone will not do.

   (b) Explain, in two or three sentences, why the near-field to far-field transform is exact rather than a curve fit. Name the earlier result it rests on.

   (c) A planar scan at 18 GHz covers a 1.5 m by 1.5 m plane at the coarsest spacing the sampling rule allows. Find the required sample spacing and the total number of sample points.

   $\Delta =$ ____

   $N =$ ____

   (d) You are handed a linearly polarized pyramidal horn and told to characterize it. List the pattern cuts and polarization configurations that make up a minimum complete characterization, state how many sweeps that is, and name one thing that set of sweeps still will not tell you.

Documentation: _____