EE 483/583 Antennas for Wireless Communications
Quiz #3 (Spring 2026)

Name KEY A

Instructions: Open book & notes. Place answers in indicated spaces and show all work for credit.

At 8.5 GHz, a vertically-polarized WR-90 X-band rectangular horn antenna has a gain of 15.4 dBi. The physical aperture of the horn is 7 cm by 16.2 cm. Find the maximum effective aperture (in cm^2) and aperture efficiency (in %) at this frequency. If a vertically-polarized EM plane wave with a power density of 420 $\mu W/m^2$ is incident from the direction of maximum gain, how much power is available to a matched load? If the horn antenna is rotated 25° from vertical, how much power will be received?

$$\lambda = \frac{c}{f} = \frac{2.99792458\times10^8}{8.5\times10^9} = 0.0352697 \text{ m} = 3.52697 \text{ cm, and } G_0 = 10^{15.4/10} = 34.673685.$$

Per (2-111), the maximum effective aperture is

$$A_{em} = e_{cd}\frac{\lambda^2}{4\pi}D_0 = \frac{\lambda^2}{4\pi}G_0 = \frac{3.52697^2}{4\pi}34.673685 \Rightarrow \underline{\boldsymbol{A_{em} = 34.323666 \text{ cm}^2}}.$$

Per (2-100), the aperture efficiency is $\varepsilon_{ap} = \frac{A_{em}}{A_p} = \frac{34.32367}{7\,(16.2)} \Rightarrow \underline{\boldsymbol{e_{ap} = 0.30268 = 30.268\ \%}}.$

Per (2-94), $A_e = \frac{P_T}{W_i} \Rightarrow P_{T,\max} = A_{em}\,W_i = 34.323666(10^{-4})420\times10^{-6}$

$$\Rightarrow \underline{\boldsymbol{P_{T,\max} = 1.44159\times10^{-6}\text{ W}}}.$$

Per (2-112), we can modify the maximum effective aperture to include PLF

$$A_{em,25^\circ} = e_{cd}\frac{\lambda^2}{4\pi}D_0\,|\,\hat{\rho}_w\bullet\hat{\rho}_a\,|^2 = \frac{\lambda^2}{4\pi}G_0 PLF = 34.323666\cos^2 25^\circ \Rightarrow \boldsymbol{A_{em,25^\circ} = 28.19325\text{ cm}^2}.$$

Per (2-94), $P_{T,\max,25^\circ} = A_{em,25^\circ}\,W_i = 28.1932466(10^{-4})420\times10^{-6}$

$$\Rightarrow \underline{\boldsymbol{P_{T,\max,25^\circ} = 1.184116\times10^{-6}\text{ W}}}.$$

max. eff. aperture = $\underline{\boldsymbol{A_{em} = 34.3237\text{ cm}^2}}$ aperture efficiency = $\underline{\boldsymbol{e_{ap} = 30.268\ \%}}$

power avail., vert. = $\underline{\boldsymbol{P_{T,\max} = 1.44159\ \mu\text{W}}}$ power avail., 25° = $\underline{\boldsymbol{P_{T,\max,25^\circ} = 1.18412\ \mu\text{W}}}$

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Quiz #3 (Spring 2026)

Name KEY B

Instructions: Open book & notes. Place answers in indicated spaces and show all work for credit.

At 8.2 GHz, a vertically-polarized WR-90 X-band rectangular horn antenna has a gain of 15.8 dBi. The physical aperture of the horn is 7 cm by 16.2 cm. Find the maximum effective aperture (in cm^2) and aperture efficiency (in %) at this frequency. If a vertically-polarized EM plane wave with a power density of 400 $\mu W/m^2$ is incident from the direction of maximum gain, how much power is available to a matched load? If the horn antenna is rotated 28° from vertical, how much power will be received?

$$\lambda = \frac{c}{f} = \frac{2.99792458\times10^8}{8.2\times10^9} = 0.03656006 \text{ m} = 3.656006 \text{ cm, and } G_0 = 10^{15.8/10} = 38.01894.$$

Per (2-111), the maximum effective aperture is

$$A_{em} = e_{cd}\frac{\lambda^2}{4\pi}D_0 = \frac{\lambda^2}{4\pi}G_0 = \frac{3.656006^2}{4\pi}38.01894 \Rightarrow \underline{\boldsymbol{A_{em} = 40.43932 \text{ cm}^2}}.$$

Per (2-100), the aperture efficiency is $\varepsilon_{ap} = \frac{A_{em}}{A_p} = \frac{40.4393}{7\,(16.2)} \Rightarrow \underline{\boldsymbol{e_{ap} = 0.356608 = 35.6608\,\%}}.$

Per (2-94), $A_e = \frac{P_T}{W_i} \Rightarrow P_{T,\max} = A_{em}\,W_i = 40.43932(10^{-4})400\times10^{-6}$

$$\Rightarrow \underline{\boldsymbol{P_{T,\max} = 1.61757\times10^{-6}\text{ W}}}.$$

Per (2-112), we can modify the maximum effective aperture to include PLF

$$A_{em,28°} = e_{cd}\frac{\lambda^2}{4\pi}D_0\,|\hat{\rho}_w\bullet\hat{\rho}_a\,|^2 = \frac{\lambda^2}{4\pi}G_0 PLF = 40.43932\cos^2 28° \Rightarrow \boldsymbol{A_{em,28°} = 31.52635\text{ cm}^2}.$$

Per (2-94), $P_{T,\max,28°} = A_{em,28°}\,W_i = 31.52635(10^{-4})400\times10^{-6}$

$$\Rightarrow \underline{\boldsymbol{P_{T,\max,28°} = 1.261054\times10^{-6}\text{ W}}}.$$

max. eff. aperture = $\underline{\boldsymbol{A_{em} = 40.4393\text{ cm}^2}}$ aperture efficiency = $\underline{\boldsymbol{e_{ap} = 35.661\,\%}}$

power avail., vert. = $\underline{\boldsymbol{P_{T,\max} = 1.61757\,\mu\text{W}}}$ power avail., 25° = $\underline{\boldsymbol{P_{T,\max,28°} = 1.26105\,\mu\text{W}}}$