⁂ Monday, January 24, 2022 ❄

EE 483/583 Antennas for Wireless Communications
Quiz #1 (Spring 2022)

Name Key A

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

The far-zone phasor electric field is $\bar{E} = \hat{a}_\phi 200\sin^2\theta\cos\phi\,\frac{e^{-j63r}}{r}$ (V/m) for an antenna located at the origin in free space. Find the time-average Poynting (power density) vector and radiation intensity. Determine the HPBW (deg) in the *x*-*z* plane. Evaluate the time-average Poynting (power density) vector and radiation intensity at point $A(r = 70\text{ m}, \theta = 70°, \phi = 30°)$.

(2-8) $\bar{W}_{ave} = \frac{1}{2}\mathrm{Re}\{\bar{E}\times\bar{H}\} = \hat{a}_r\frac{|\bar{E}|^2}{2\eta}$ ← from e^{-j63r} term $\quad |\bar{E}|^2 = \bar{E}\cdot\bar{E}^*$ $\quad \eta = \eta_0 = 376.73\,\Omega$

$\bar{W}_{ave} = \hat{a}_r\frac{200^2\sin^4\theta\cos^2\phi\,(1)}{2(376.73)r^2} = \hat{a}_r\frac{53.0883765\sin^4\theta\cos^2\phi}{r^2}\left(\frac{W}{m^2}\right)$

(2-12) $U = r^2 W_{rad} = \left(\frac{r^2}{r^2}\right)^{1} 53.0884\sin^4\theta\cos^2\phi\ (W/sr)$

Set $U = U_{max}/2$ & note for $\phi = 0$ or $180°$ that $\cos^2\phi = 1$

$53.0884\sin^4\theta_h\,(1) = \frac{1}{2}(53.0884) \Rightarrow \sin^4\theta_h = 0.5$

$\Rightarrow \theta_h = \sin^{-1}(0.5^{1/4}) = 57.2349°$ or $122.7651°$

$HPBW = 122.7651 - 57.2349 = 65.53°$

$\bar{W}_{ave,A} = \hat{a}_r\frac{53.0884\sin^4 70°\cos^2 30°}{70^2} = \hat{a}_r\,0.0063359\ (W/m^2)$

$U_A = 70^2|\bar{W}_{ave,A}| = 70^2(0.0063359) = 31.04588\ (W/sr)$

time-ave Poynting vector = $\hat{a}_r\frac{53.088\sin^4\theta\cos^2\phi}{r^2}\left(W/m^2\right)$

radiation intensity = $53.088\sin^4\theta\cos^2\phi\ (W/sr)$ HPBW = $65.53°$

@ *A*, time-ave Poynting vector = $\hat{a}_r\,6.336\ (mW/m^2)$ rad. intensity = $31.046\ (W/sr)$