Scheme of Evaluation IAT-1

Subject : Antennas and Propagation (10TE63)

1. Definitions — Each definition with fig. & equations — 2M

2 a)

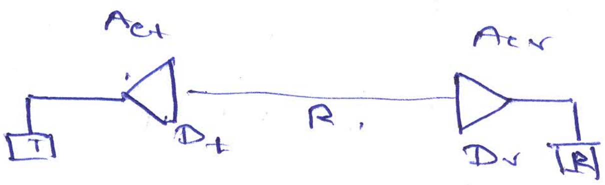


Fig. — 1M

Upto $\dfrac{D_t}{D_r} = \dfrac{A_{ct}}{A_{cr}}$ — 3M

Arriving at $D = \dfrac{4\pi}{\lambda^2} A_{em}$ — 2M

b) $R = 0.5\ km$, $f = 1\ GHz$, $P_r = 10.8\ mW$

$P_t = ?$, $G_t = 25\ dB$, $G_r = 20\ dB$.

$10 \log_{10} G_t = 25 \Rightarrow G_t = 10^{2.5} = 316.22$

$|||^{ly}$ $G_r = 10^2 = 100$

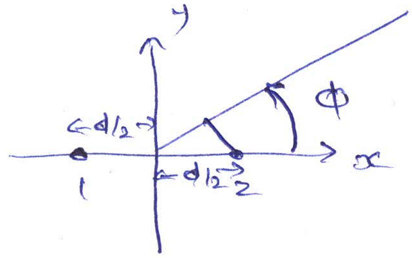
$\lambda = \dfrac{c}{f} = \dfrac{3\times10^8}{1\times10^9} = 0.3\ m$

$\dfrac{P_r}{P_t} = G_t G_r \left(\dfrac{\lambda}{4\pi R}\right)^2$

$P_t = \dfrac{P_r}{G_t G_r}\left(\dfrac{4\pi R}{\lambda}\right)^2 = \dfrac{10.8\times10^{-3}}{316.22 \times 100}\left(\dfrac{4\pi\times0.5\times10^3}{0.3}\right)$

$\cong 15\ kW$

3.



— 1M.

$E_1 = E_0 e^{-j\psi/2}$

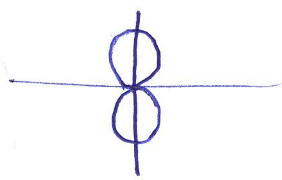
$E_2 = E_0 e^{j\psi/2}$ $\Rightarrow E = E_1 + E_2$ — 3M

Vector Diagram — 1M.

$E = \cos\left(\frac{\pi}{2}\cos\phi\right)$ — 1M

Peaks, Nulls & HP Points — 3M

Pattern — 1M.



4 (a).

$U = U_m \cos^2\theta \sin^3\phi$ $\quad 0 \le \theta \le \pi,$
$\quad 0 \le \phi \le \pi.$

$P_{rad} = \iint U \, d\Omega$

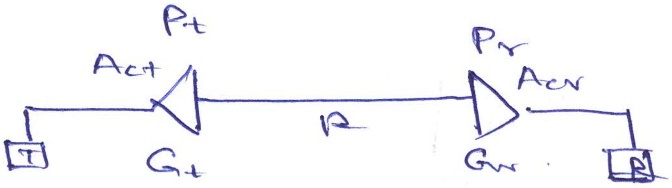
$= U_m \int_{\phi=0}^{\pi} \int_{\theta=0}^{\pi} \cos^2\theta \sin^3\phi \sin\theta \, d\theta \, d\phi$

$= U_m \int_{\phi=0}^{\pi} \sin^3\phi \, d\phi \int_{\theta=0}^{\pi} \cos^2\theta \sin\theta \, d\theta$

$= U_m \; I_1 \times I_2$ (i) — 1M

$I_1 = \int_{\phi=0}^{\pi} \sin^3\phi \, d\phi$

4 b)



— 1M.

$$S_{ot} = \frac{P_t}{4\pi R^2}$$

$$S_t = \frac{P_t G_t}{4\pi R^2} \qquad - 2M$$

$$P_r = S_t A_{er} = \frac{P_t G_t A_{er}}{4\pi R^2}$$

$$\frac{P_r}{P_t} = \frac{G_t}{4\pi R^2} \cdot \frac{G_r \lambda^2}{4\pi} \qquad D = G = \frac{4\pi A_e}{\lambda^2}$$

$$= G_t G_r \left(\frac{\lambda}{4\pi R}\right)^2 \qquad - 5M.$$

5. Broadside Array (Equal Amplitude and in-phase).

$$E_n = \frac{1}{n} \frac{\sin\left(\frac{n\psi}{2}\right)}{\sin\left(\frac{\psi}{2}\right)}, \qquad \delta = 0, \quad n = 4.$$

$d = \frac{\lambda}{2}$

$d_r = \frac{2\pi d}{\lambda} = \frac{2\pi}{\lambda} \cdot \frac{\lambda}{2} = \pi$

Peaks (ϕ_m):

E is max. at $\psi = 0$

$\psi = d_r \cos\phi + \delta$

$0 = \pi \cos\phi_m + 0$

$\Rightarrow \phi_m = 90°, 270°$

Nulls (ϕ_0)

$E = 0.$

$$\sin\left(\frac{n\psi}{2}\right) = 0$$

$$\frac{n\psi}{2} = \pm k\pi$$

$$\psi = \pm \frac{2k\pi}{n}$$

$$\cancel{\pi}\cos\phi_0 = \pm \frac{2k\cancel{\pi}}{n} = \pm \frac{2k}{4}$$

$$= \pm \frac{k}{2}$$

$$\phi_0 = \cos^{-1}\left(\pm \frac{k}{2}\right)$$

$k = 0$, $\phi_0 = 0', 180'$

$k = 1$, $\phi_0 = 60', 120', 240', 300'$

$k = 2$, $\phi_0 = 90', 270'$ (Discard) $\because$ Peaks are present

Side lobes (ϕ_{SL})

$$\sin\left(\frac{n\psi}{2}\right) = 1$$

$$\frac{n\psi}{2} = \pm (2k+1)\frac{\pi}{2}$$

$$\psi = \pm \frac{(2k+1)\pi}{n}$$

$$\cancel{\pi}\cos\phi_{SL} = \pm \frac{(2k+1)\cancel{\pi}}{n} = \pm \left(\frac{2k+1}{4}\right)$$

$$\phi_{SL} = \cos^{-1}\left\{\pm \left(\frac{2k+1}{4}\right)\right\}$$

$k = 0$, $\phi_{SL} = 75.52', 104.47',$
$284.48'\ 255.52'$

$k = 1$, $\phi_{SL} = 41.4, 318.59°,$
$138.59, 221.4$

~~Rad~~

Peaks of Side lobes

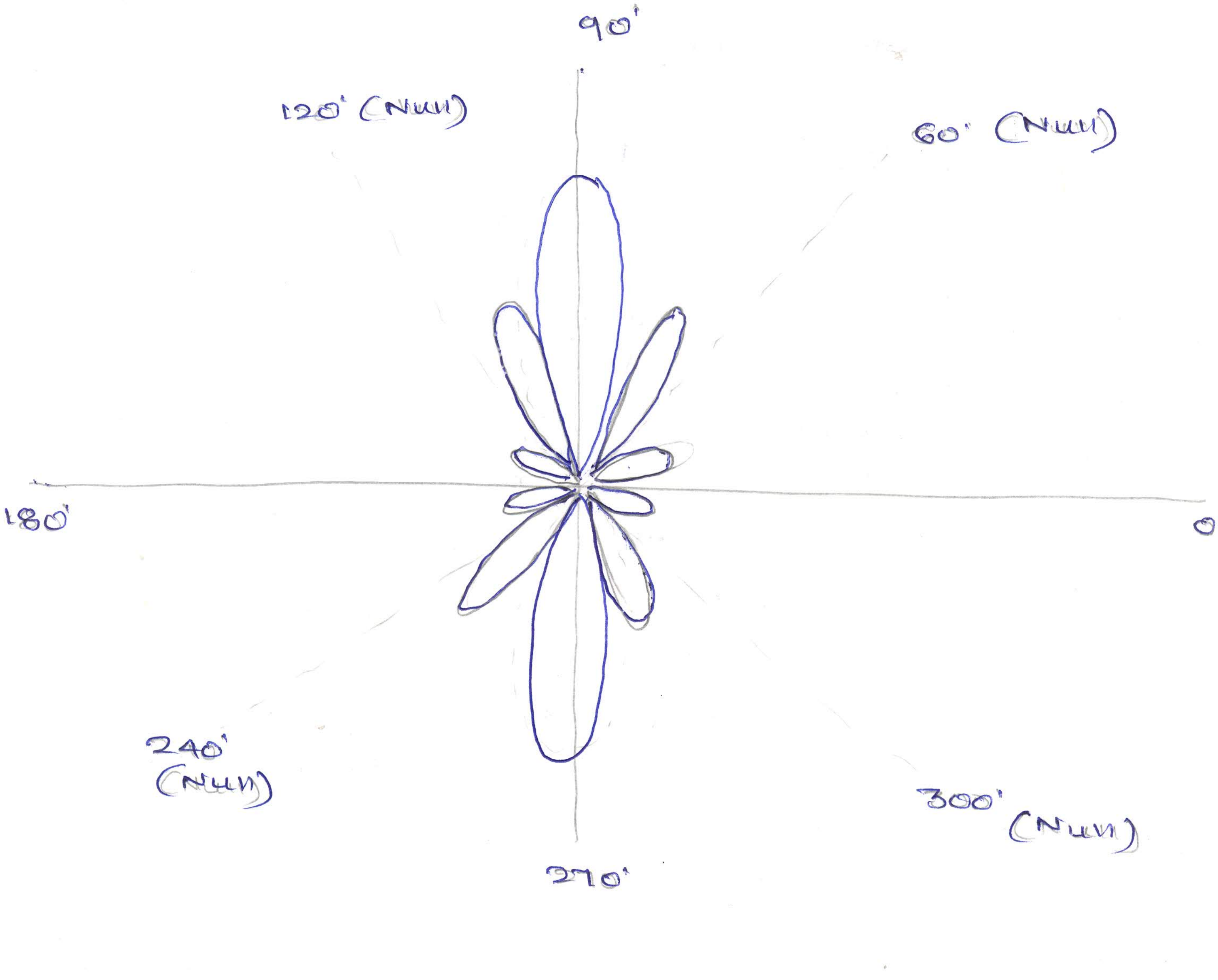
$$E_n = \frac{1}{n \sin\left(\frac{\psi}{2}\right)}$$

$$= \frac{1}{4 \sin\left\{\pm \frac{(2k+1)\pi}{2n}\right\}} = \frac{1}{4 \sin\left\{\pm \frac{(2k+1)\pi}{8}\right\}}$$

$k = 0$, $E_n = 0.65$

$k = 1$, $E_n = 0.27$.

Radiation Pattern (Plot of E_n vs ϕ)



6. $n = 8$, $d = \frac{\lambda}{6}$, $\delta = \frac{\pi}{3}$.

Pattern = ?, BWFN = ?, HPBW = ?.

$$E_n = \frac{\sin\left(\frac{n\psi}{2}\right)}{n \sin\left(\frac{\psi}{2}\right)}$$

Peaks (ϕ_m):

$E \to E_{max}$ when $\psi = 0$

$\psi = 0 = d_r \cos\phi_m + \delta$

$d_r = \frac{2\pi}{\lambda} d = \frac{2\pi}{\lambda} \times \frac{\lambda}{\cancel{6}\,3} = \frac{\pi}{3}$

$\frac{\pi}{3} \cos\phi_m + \frac{\pi}{3} = 0$

$\Rightarrow \frac{\pi}{3}(\cos\phi_m + 1) = 0$

$\cos\phi_m + 1 = 0$

$\cos\phi_m = -1$

$\phi_m = \cos^{-1}(-1)$

$= 180°$

Nulls (ϕ_0)

$E_n = 0$

$\sin\left(\frac{n\psi}{2}\right) = 0$

$\frac{n\psi}{2} = \pm k\pi$

$\psi = \pm \frac{2k\pi}{n}$

$$\frac{\cancel{\pi}}{3}(\cos\phi_0 + 1) = \pm\frac{2k\pi}{n}$$

$$= \pm\frac{\cancel{2}k\cancel{\pi}}{\cancel{4}84}$$

$$\cos\phi_0 + 1 = \pm\frac{3k}{4}$$

$$\cos\phi_0 = \pm\frac{3k}{4} - 1$$

$$\phi_0 = \cos^{-1}\left(\pm\frac{3k}{4} - 1\right)$$

$k = 0$, $\phi_0 = 180'$ (Discard).

$k = 1$ $\phi_0 = 104.47^\circ, 255.5^\circ$

Side lobes (ϕ_{SL}).

$$\sin\left(\frac{n\psi}{2}\right) = 1$$

$$\frac{n\psi}{\cancel{2}} = \pm(2k+1)\frac{\pi}{\cancel{2}}$$

$$\psi = \pm(2k+1)\frac{\pi}{n} = \pm(2k+1)\frac{\pi}{8}$$

$$\frac{\cancel{\pi}}{3}(\cos\phi_0 + 1) = \pm(2k+1)\frac{\cancel{\pi}}{8}$$

$$\cos\phi_0 + 1 = \pm\frac{3}{8}(2k+1).$$

$$\cos\phi_0 = \pm\frac{3}{8}(2k+1) - 1$$

$$\phi_0 = \cos^{-1}\left\{\pm\frac{3}{8}(2k+1) - 1\right\}$$

$= 128.68', 231.31^\circ, 28.95^\circ,$

$331.04'$

Peaks of Side lobes

$$E_n = \frac{\sin\left(\frac{n\psi}{2}\right)}{n\sin\left(\frac{\psi}{2}\right)} = \frac{1}{n\sin\left(\frac{\psi}{2}\right)}$$

$$= \frac{1}{n\sin\left\{\pm\frac{(2k+1)\pi}{2n}\right\}}$$

$$E_n = \frac{1}{8\sin\left\{\pm\frac{(2k+1)\pi}{16}\right\}}$$

$k = 0$, $E_n = 0.64$

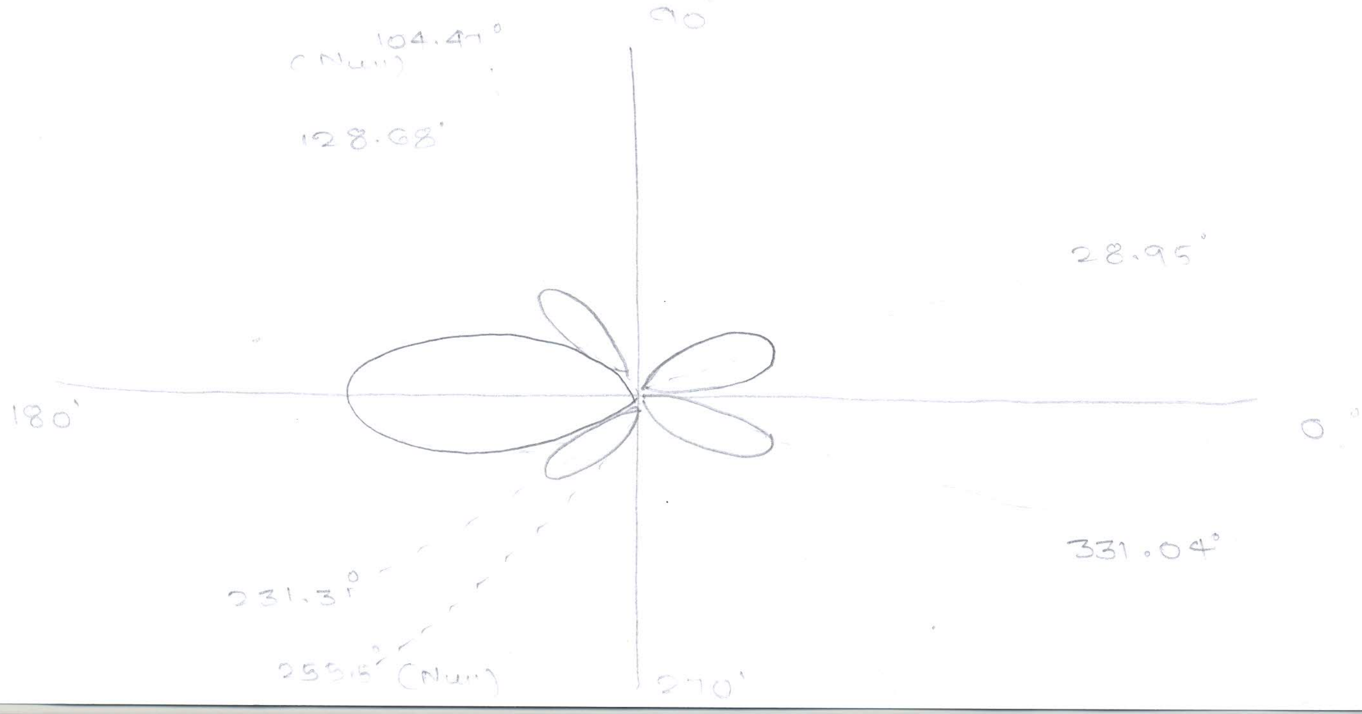
$k = 1$, $E_n = 0.21$

$k = 2$, $E_n = 0.12$

$k = 3$, $E_n = 0.09$

$k = 4$, $E_n = 0.07$

Radiation Pattern



7 a) $U(\theta, \phi) = U_m \cos^4\theta \sin^2\phi$

$0 \leq \theta < \pi/2, \quad 0 < \phi < 2\pi$

$$P_{rad} = \iint U \, d\Omega$$

$$= \int_{\phi=0}^{2\pi} \int_{\theta=0}^{\pi} U_m \cos^4\theta \sin^2\phi \sin\theta \, d\theta \, d\phi$$

$$= U_m \int_{\theta=0}^{2\pi} \cos^4\theta \sin\theta \, d\theta \int_{\phi=0}^{2\pi} \sin^2\phi \, d\phi$$

$$= U_m \, I_1 \times I_2 \quad \rightarrow 1M$$

$$I_1 = \int_{\theta=0}^{\pi} \cos^4\theta \sin\theta \, d\theta$$

Let $\cos\theta = t$

$-\sin\theta \, d\theta = dt$

when $\theta = 0, \ t = 1$

when $\theta = \pi, \ t = -1$

$$I_1 = \int_{t=1}^{-1} t^4 (-dt) = \int_{t=-1}^{1} t^4 \, dt$$

$$= \left. \frac{t^5}{5} \right]_{-1}^{1} = \frac{1}{5} - \left(-\frac{1}{5}\right)$$

$$= \frac{2}{5} \rightarrow 2M$$

$$\sin^2\theta = \frac{1 - \cos 2\theta}{2}$$

$$I_2 = \frac{1}{2} \int_{\phi=0}^{2\pi} (1 - \cos 2\phi) \, d\phi$$

$$= \frac{1}{2} \left\{ \left. \phi \right]_{\phi=0}^{2\pi} - \left. \frac{\sin 2\phi}{2} \right]_{\phi=0}^{2\pi} \right\}$$

$$= \frac{1}{2} \{ (2\pi - 0) - 0 \} = \pi$$

$$P_{rad} = U_m \times \frac{1}{5} \times \pi$$

$$= \frac{\pi U_m}{5} \quad (1)$$

$$P_{rad\text{-}Isotropic} = P_0 = 4\pi U_0 \quad (2) \quad - 1M$$

$$\frac{\pi U_m}{5} = 4\pi U_0$$

$$D = \frac{U_m}{U_0} = 4 \times 5$$
$$= 20 \quad - 2M$$

7 b). Definition of Voltage Induced

- 2M.

Arriving at $D = 0.13\lambda^2$ - 2M

8. $n = 4$, $d = \frac{\lambda}{2}$, $\delta = -d_r$.

$d_r = \frac{2\pi}{\lambda} \cdot \frac{\lambda}{2}$
$= \pi$

Peaks

$$\psi = d_r \cos\phi_m + \delta = 0$$

$$\frac{2\pi}{\lambda} \cdot \frac{\lambda}{2} \cos\phi_m - d_r = 0$$

$$\pi(\cos\phi_m - 1) = 0$$

$$\cos\phi_m = 1$$

$$\phi_m = \cos^{-1} 1 = 0°, 180°$$

- 2M

Nulls

$$\left(\frac{n\psi}{2}\right) = \pm k\pi$$

$$\psi = \pm \frac{2k\pi}{n}$$

$$\pi(\cos\phi_0 - 1) = \pm \frac{2k\pi}{4}$$

$$\cos\phi_0 = 1 \pm \frac{k}{2}$$

$$\phi_0 = \cos^{-1}\left(1 \pm \frac{k}{2}\right)$$

$$= 60^\circ, 90^\circ, 120^\circ, 240^\circ, 270^\circ, 300^\circ$$

– 2M

Side lobes

$$\left(\frac{n\psi}{2}\right) = \pm (2k+1)\frac{\pi}{2}$$

$$\psi = \pm \frac{(2k+1)\pi}{n}$$

$$\cancel{\pi}(\cos\phi_{SL} - 1) = \pm \frac{(2k+1)\cancel{\pi}}{n}$$

$$\cos\phi_{SL} = 1 \pm \frac{(2k+1)}{4}$$

$k = 1$, $\phi_{SL} = 75.52^\circ, 284.47^\circ$

$k = 2$, $\phi_{SL} = 104.47^\circ, 255.52^\circ$

– 2M

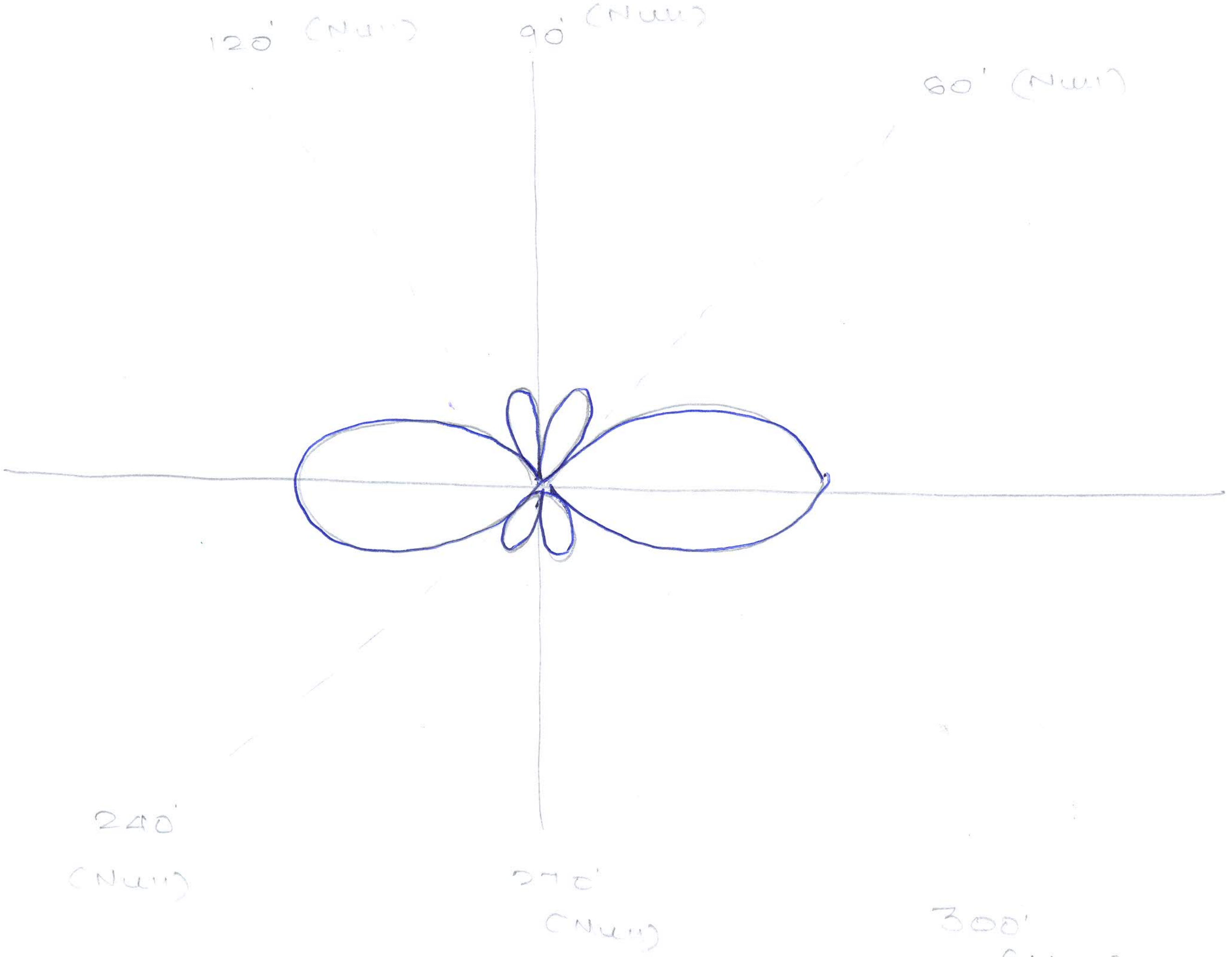
Peaks of side lobes

For $k=1$, $E_n = \dfrac{1}{4\sin\left\{\frac{\pm(2k+1)\pi}{8}\right\}}$

$= 0.21$

For $k=2$, $E_n = 0.27$ – 2M

Radiation Pattern



← 2M