2 Homework Problems

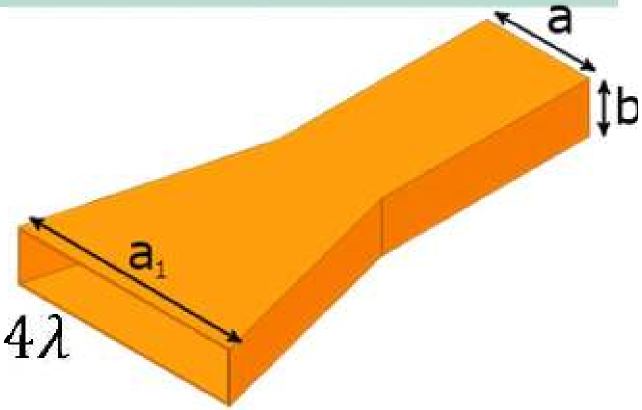
Homework Problem 1

1. Find the flare angle of an H-plane sectoral horn antenna such that the maximum phase deviation across the aperture is 43° and with physical dimensions of $a = 0.4\lambda$, b $= 0.25\lambda$, and $a_1 = 2.5\lambda$

- $\Delta\phi_{max} = k\delta(x')\big|_{x'=a_1/2} = \dfrac{k\left(a_1/2\right)^2}{2\rho_1}$
- $(43^{\circ})\left(\dfrac{\pi}{180}\right) = \dfrac{k\left(a_1/2\right)^2}{2\rho_1}$
- $\dfrac{k}{2\rho_1} = \left(\dfrac{43\pi}{180}\right)\left(\dfrac{4}{a_1^2}\right)$
- $\dfrac{1}{\rho_1} = \left(\dfrac{43\pi}{180}\right)\left(\dfrac{8}{ka_1^2}\right)$
- $\rho_1 = \left(\dfrac{180}{43\pi}\right)\left(\dfrac{(2\pi\lambda)a_1^2}{8}\right) = \left(\dfrac{180}{43}\right)\left(\dfrac{\lambda a_1^2}{4}\right) = 6.54\lambda$

$$\Delta\phi_{max} = k\delta\left(x'\right)\Big|_{x'} = \frac{kx'^2}{2\rho_1}$$

$$2\psi_e = 2\tan^{-1}\left(\frac{a_1/2}{\rho_1}\right)$$



Practice Problem 1 cont.

- $2\psi_e = 2\tan^{-1}\left(\frac{a_1/_2}{\rho_1}\right)$
- $2\psi_e = 2\tan^{-1}\left(\frac{1.25}{6.54}\right)$
- $2\psi_e = 21.64^{\circ}$

Homework Problem 2

2. Design a Yagi antenna using a half-wave dipole as the driven element with one reflector and one director, as well as find the ${}^{F}/_{B}$ ratio given the forward and backward power of $P_f = 15dB$ and $P_b = -2dB$ at 17GHz

$${}^{F}/_{B} = 10\log\left({}^{P_f}/_{P_b}\right)$$
$$RE = 1.05 * DE$$
$$DI = 0.95 * DE$$

- $DE = 0.5\lambda = 0.5\left(\frac{c}{17GHz}\right) = 8.82mm$
- $RE = 1.05(8.82mm) = 9.26mm$
- $DI = 0.95(30mm) = 8.38mm$
- ${}^{F}/_{B} = 10\log({}^{15dB}/_{-2dB}) = 10\log({}^{5.623}/_{0.794})$
- ${}^{F}/_{B} = 8.501dB$

Homework Problem 3

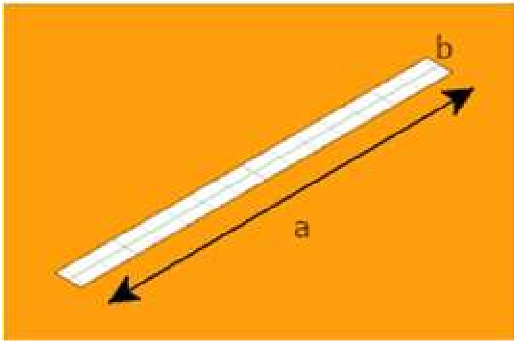
3. With a rectangular aperture situated on a ground plane with a directivity of 40 and a half power bandwidth of 40° at 7GHz, find the dimensions of the aperture

- $D_0 = \frac{4\pi}{\lambda^2} Area = \frac{4\pi ab}{\lambda^2}$
- $ab = \frac{D_0 \lambda^2}{4\pi}$
- $a = \frac{D_0 \lambda^2}{4b\pi}$
- $HPBW = \frac{50.6}{b/_\lambda} \rightarrow {}^{b}/_{\lambda} = \frac{50.6}{HPBW}$
- $b = \frac{50.6}{HPBW} \lambda = 1.265\lambda$
- $a = \frac{D_0 \lambda^2}{4b\pi} = \frac{(40)\lambda^2}{4(1.265\lambda)\pi} = 2.516\lambda$

$$D_0 = \frac{4\pi}{\lambda^2} Area$$

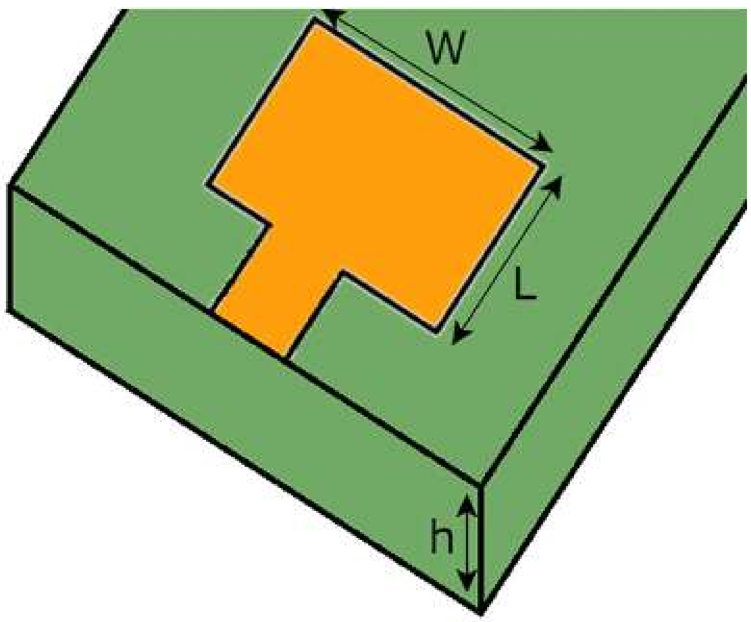
$$HPBW = \frac{50.6}{b/_\lambda}$$

$$FNBW = \frac{114.6}{b/_\lambda}$$



Homework Problem 4

4. Design a rectangular, microstrip patch antenna placed on a substrate with $\varepsilon_r = 5$ and thickness of $h = 5mm$ at 2.5GHz, with no inset feeding



$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \frac{1}{\sqrt{1 + 12\, {}^{h}/_{W}}}$$

$$W = \frac{\lambda}{2} \sqrt{\frac{2}{\varepsilon_r + 1}}$$

$$\Delta L = 0.412h \frac{\varepsilon_{reff} + 0.3\left({}^{W}/_{h} + 0.264\right)}{\varepsilon_{reff} - 0.258\left({}^{W}/_{h} + 0.8\right)}$$

$$L = \frac{\lambda}{2\sqrt{\varepsilon_{reff}}} - 2\Delta L$$

Homework Problem 4 cont.

- $W = \frac{\lambda}{2}\sqrt{\frac{2}{\varepsilon_r+1}} = \frac{(0.12m)}{2}\sqrt{\frac{2}{(5)+1}}$
- $W = 34.64mm$
- $\varepsilon_{reff} = \frac{(5)+1}{2} + \frac{(5)-1}{2}\frac{1}{\sqrt{1+12^{(5mm)}/_{(34.64mm)}}}$
- $\varepsilon_{reff} = 4.21$
- $\Delta L = 0.412(5mm)\frac{(4.21)+0.3\left(^{(34.64mm)}/_{(5mm)}+0.264\right)}{(4.21)-0.258\left(^{(34.64mm)}/_{(5m\quad)}+0.8\right)}$
- $\Delta L = 19.19mm$
- $L = \frac{\lambda}{2\sqrt{\varepsilon_{reff}}} - 2\Delta L = \frac{(0.12m)}{2\sqrt{(4.21)}} - 2(19.19mm)$
- $L = 10.05mm$