Solution 4.12

4.12
Two directional antennas are aligned facing each other in the boresight direction at 1800 MHz in free-space conditions, as shown in Figure 4.26. Antenna A is a parabolic dish with 65 % radiation efficiency, and antenna B is a horn antenna which has a gain of 15 dBi.

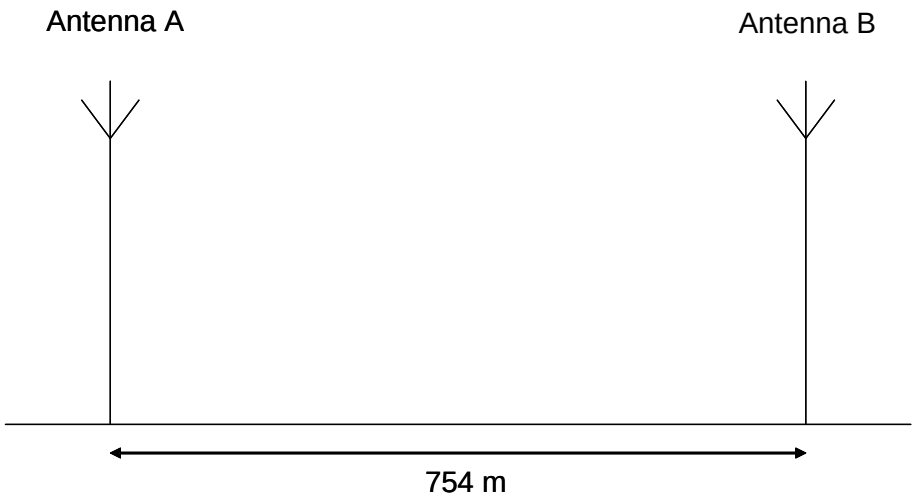


Fig. 4.26

The text book provides the following two equations for reflector antennas where D is the reflector antenna diameter and η the efficiency:

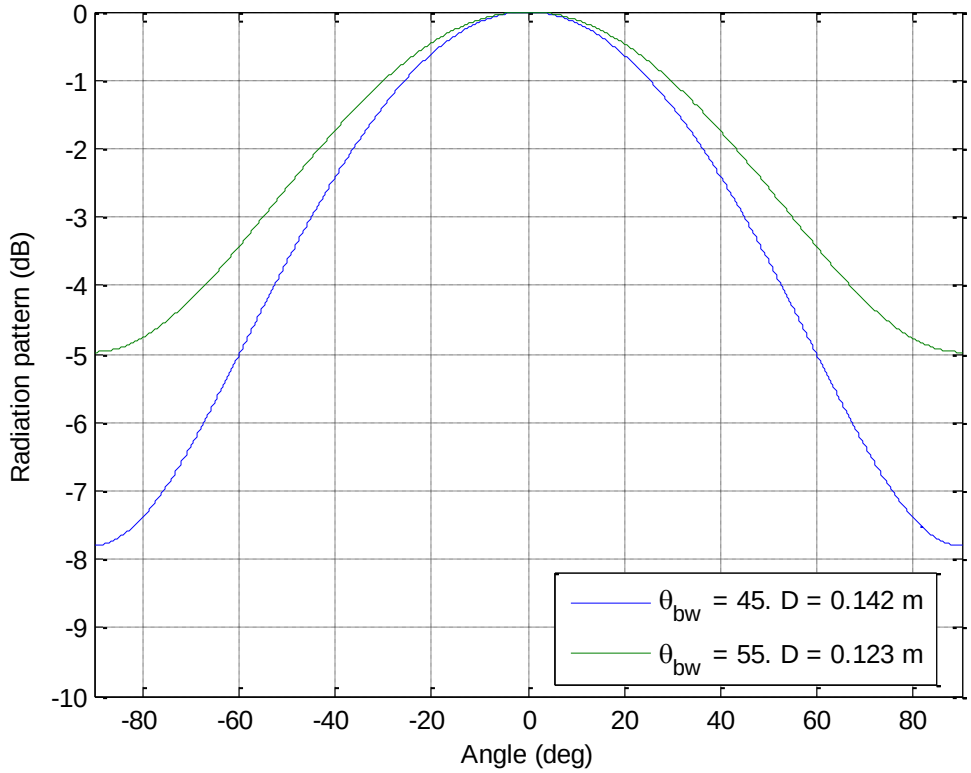
$$P = \frac{\sin\left(\frac{\pi D \cos\phi}{\lambda}\right)}{\frac{\pi D \cos\phi}{\lambda}} \quad \text{and} \quad G = \eta\left(\frac{\pi D}{\lambda}\right)^2$$

Determine
a) The radiation pattern cuts of azimuth and elevation angle for Antenna A, assuming a vertical beamwidth of 45° and a horizontal beamwidth of 55°. You can assume that some side and back lobes for both azimuth and elevation planes are significant.
b) The directivity for antenna A, in decibels.
c) The power received at antenna B, given that antenna A has an input power of 1 W. State clearly any assumptions made.
d) The distance at which antenna B is considered to be in the far-field, if this antenna has a diagonal distance in its mouth of 10 cm.
e) If antenna B is used as a transmit antenna, what is the power received at antenna A given an input power of 1 W? Explain your answer.

Solution

a) Find the antenna diameters D using the equations quoted, information given about beamwidth, which is the half power (3 dB below maximum) levels. It involves finding x where $\sin x/x=0.5$ and then D from $x=\pi D\cos\theta/\lambda$.

   Then find the vertical and horizontal plots from the same equation (note the shift of 90 deg to get maximum at 0 deg).



b) The directivity is defined as power gain = efficiency * directivity, and an approximate value given for large antennas as:
directivity = 41000/vertical beamwidth(deg)/horizontal beamwidth(deg).
Antenna A directivity: 12.2 dB

c) Link budget: 1 W, i.e., 0 dBW + transmit antenna gain – free space loss + receive antenna gain. Free space loss L = 32.4 + 20*log1800 + 20*log0.754.
Power received with antenna B: -69.3 dBW

d) Distance to the far field: 2*L^2/λ, where L is the diameter of the smallest sphere which completely encloses the antenna.
Distance to the far-field for antenna B: 0.12 m

e) Same as in c) due to reciprocity.