9.33 An antenna with a circular aperture has a circular beam with a beamwidth of 3° at 20 GHz.

(a) What is the antenna directivity in dB?

(b) If the antenna area is doubled, what will be the new directivity and new beamwidth?

(c) If the aperture is kept the same as in (a), but the frequency is doubled to 40 GHz, what will the directivity and beamwidth become then?

Solution:

(a) From Eq. (9.96),

$$D \simeq \frac{4\pi}{\beta^2} = \frac{4\pi}{(3^\circ \times \pi/180^\circ)^2} = 4.59 \times 10^3 = 36.6 \text{ dB}.$$

(b) If area is doubled, it means the diameter is increased by $\sqrt{2}$, and therefore the beamwidth decreases by $\sqrt{2}$ to

$$\beta = \frac{3^\circ}{\sqrt{2}} = 2.2^\circ.$$

The directivity increases by a factor of 2, or 3 dB, to $D = 36.6 + 3 = 39.6$ dB.

(c) If f is doubled, λ becomes half as long, which means that the diameter to wavelength ratio is twice as large. Consequently, the beamwidth is half as wide:

$$\beta = \frac{3^\circ}{2} = 1.5^\circ,$$

and D is four times as large, or 6 dB greater, $D = 36.6 + 6 = 42.6$ dB.