RADIATION PATTERNS

Radiation Pattern

A mathematical and/or graphical representation of the radiation properties of an antenna, such as the:

- amplitude
- phase
- polarization, etc.

as a function of the angular space coordinates θ, ϕ.

Amplitude Radiation Pattern

- Field Pattern:

  A plot of the field (either electric $|\underline{E}|$ or magnetic $|\underline{H}|$) on a *linear* scale

- Power Pattern:

  A plot of the power (proportional to either the electric $|\underline{E}|^2$ or magnetic $|\underline{H}|^2$ fields) on a *linear* or *decibel (dB)* scale.

Polar Pattern

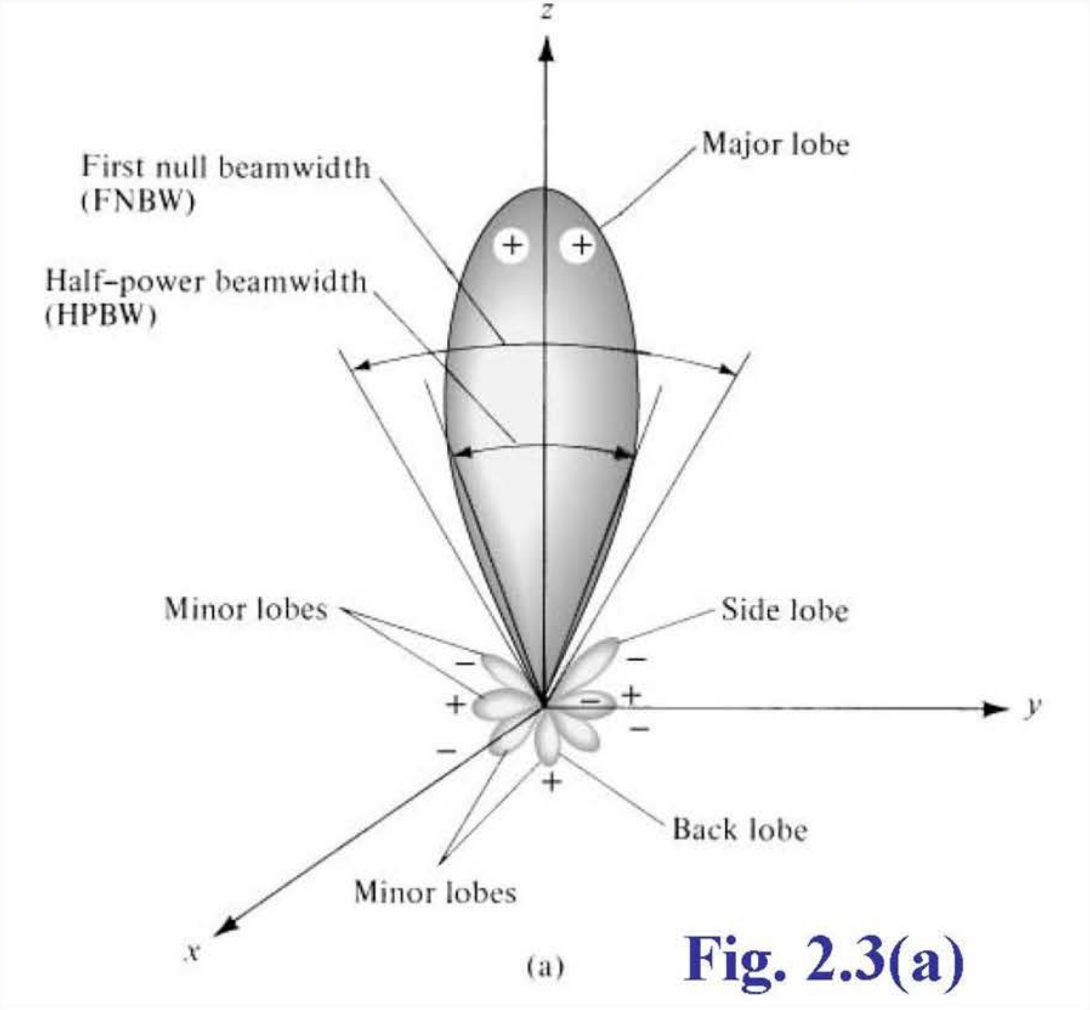


Fig. 2.3(a)

Linear Pattern

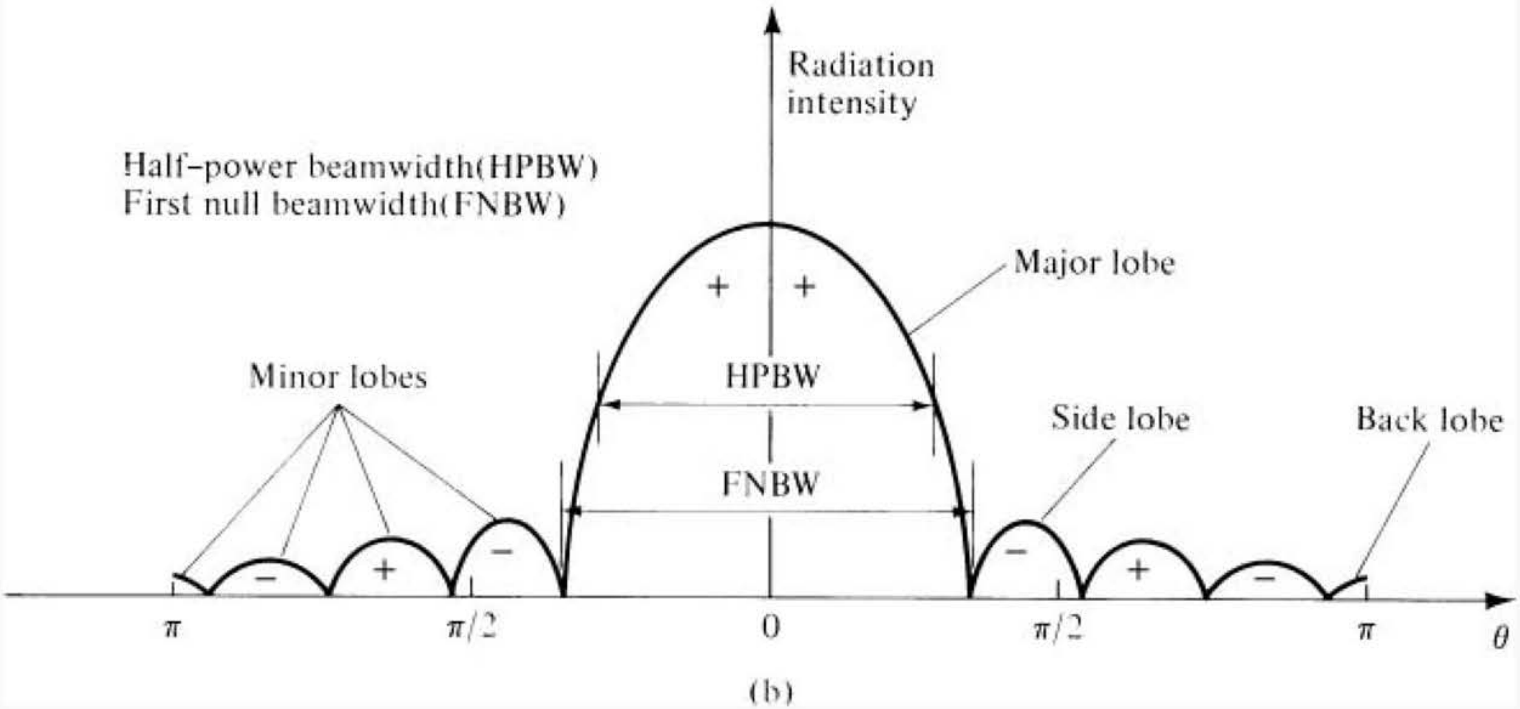
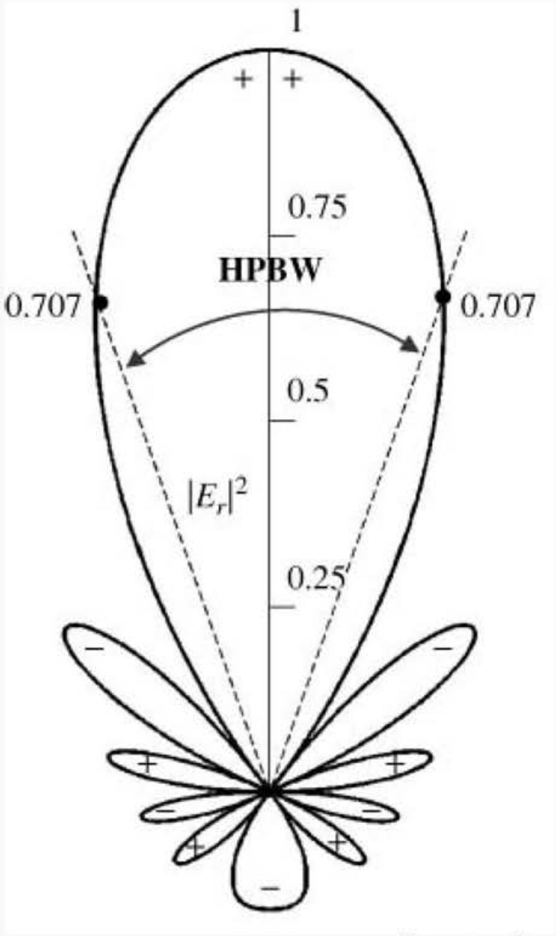


Fig. 2.3(b)

2-D Normalized *Field* $|\underline{E}_n|$ Pattern of a Linear Array



Linear Scale

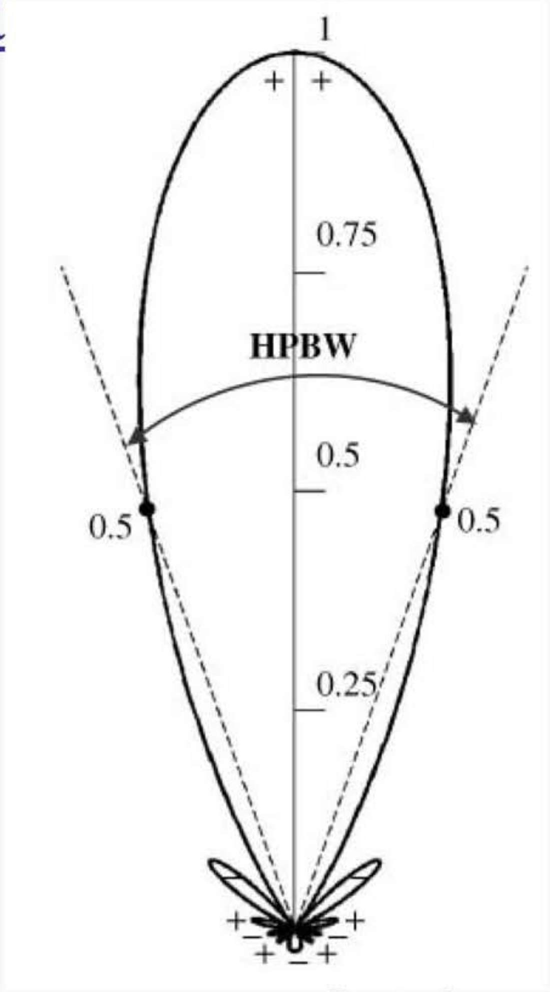
N = 10 elements

$d = \lambda/4$ spacing

HPBW = 38.64°

Fig. 2.2(a)

2-D Normalized *Power* $|\underline{E}_n|^2$ Pattern of a Linear Arra



Linear Scale

N = 10 elements

$d = \lambda/4$ spacing

HPBW = 38.64°

Fig. 2.2(b)

2-D Normalized *Power* $|\underline{E}_n|^2$ Pattern of a Linear Array

dB Scale

$N = 10$ element

$d = \lambda/4$ spacing

HPBW = 38.64°

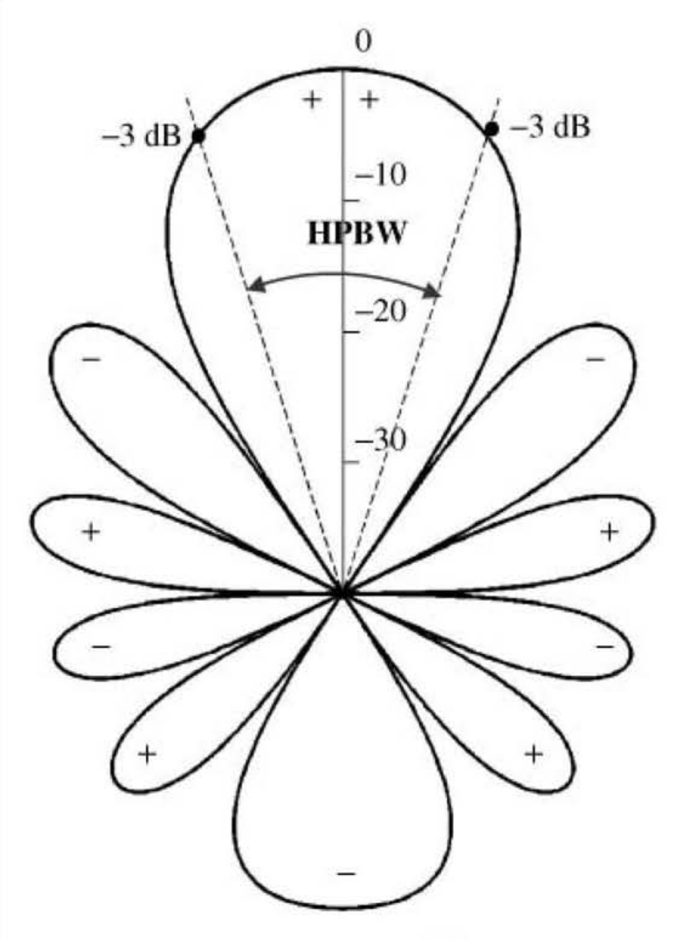


Fig. 2.2(c)

ISOTROPIC, DIRECTIONAL & OMNIDIRECTIONAL

Directional Pattern of a Horn

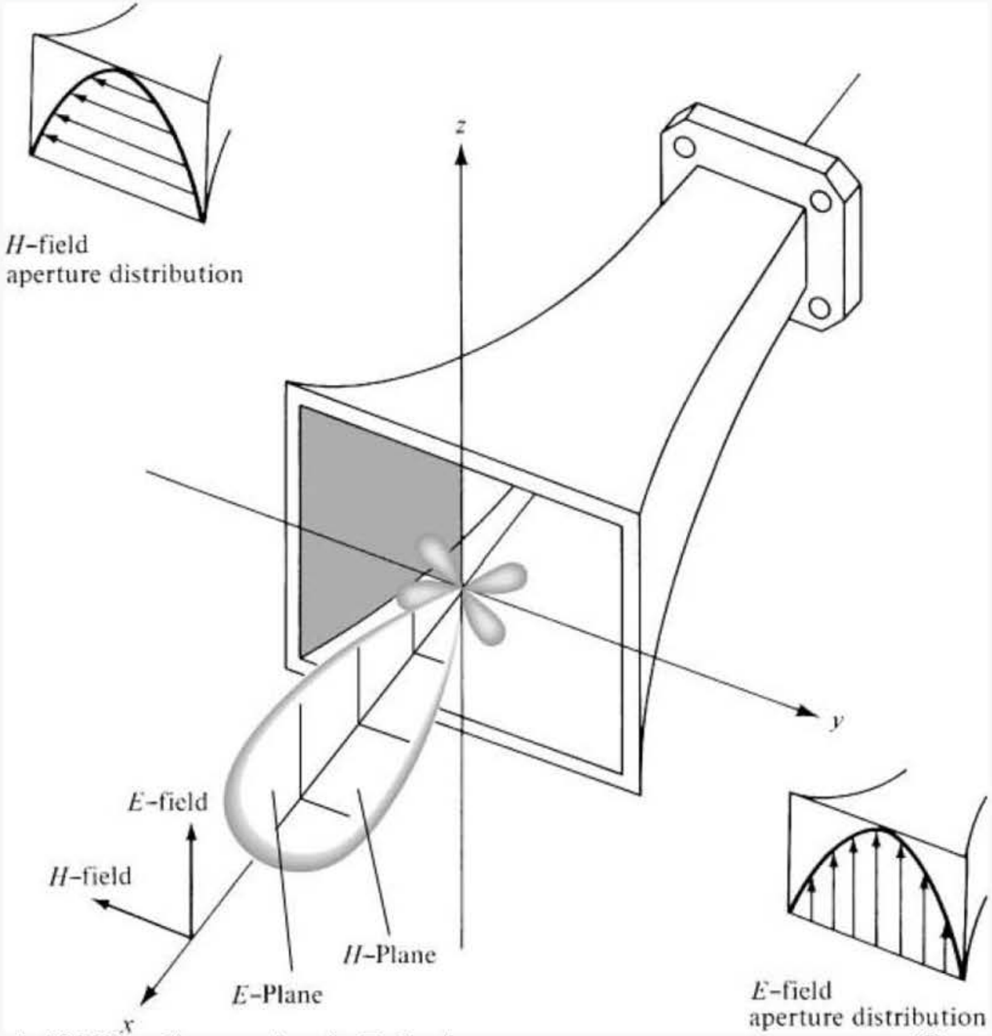


Fig. 2.5

Fix $\theta = \frac{\pi}{2}$:
Non-Directional

Fixed ϕ:
Directional

Net: Omni-directional

E-plane: plane containing E-field vector & direction of max radiation.

Also, H-plane

Omnidirectional Pattern

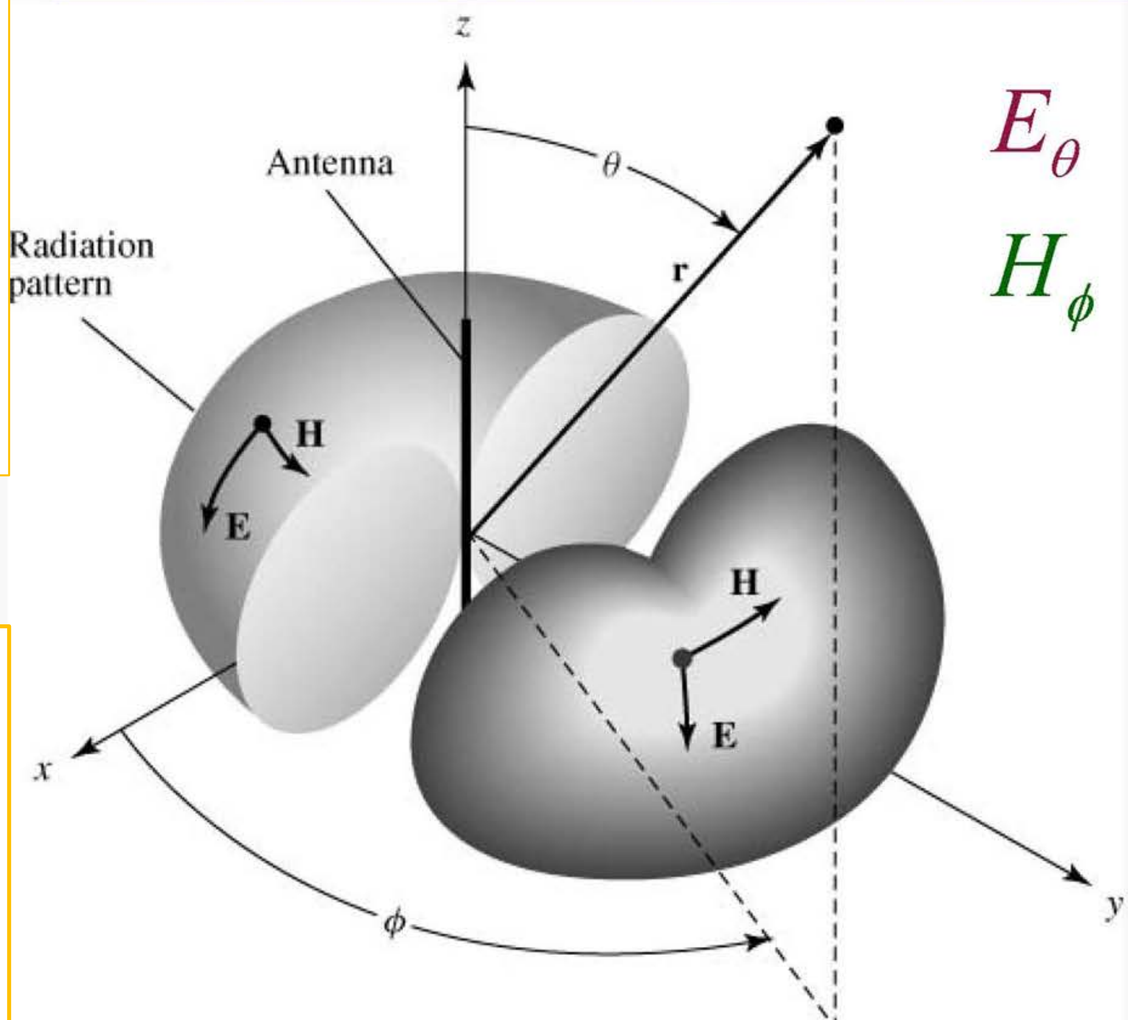
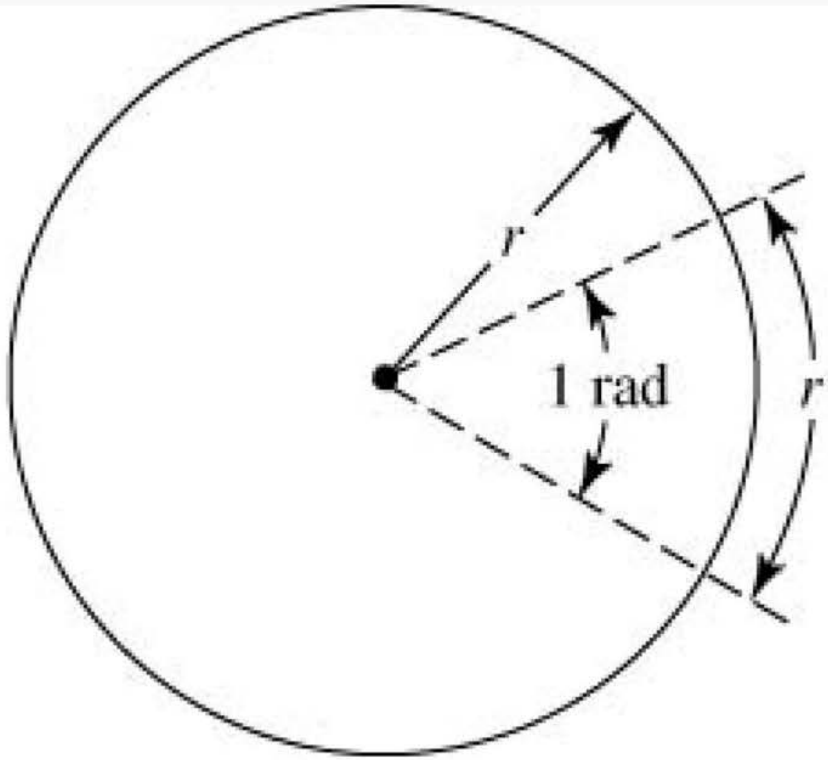


Fig. 2.6

ANGLES IN 2D & 3D

Radian



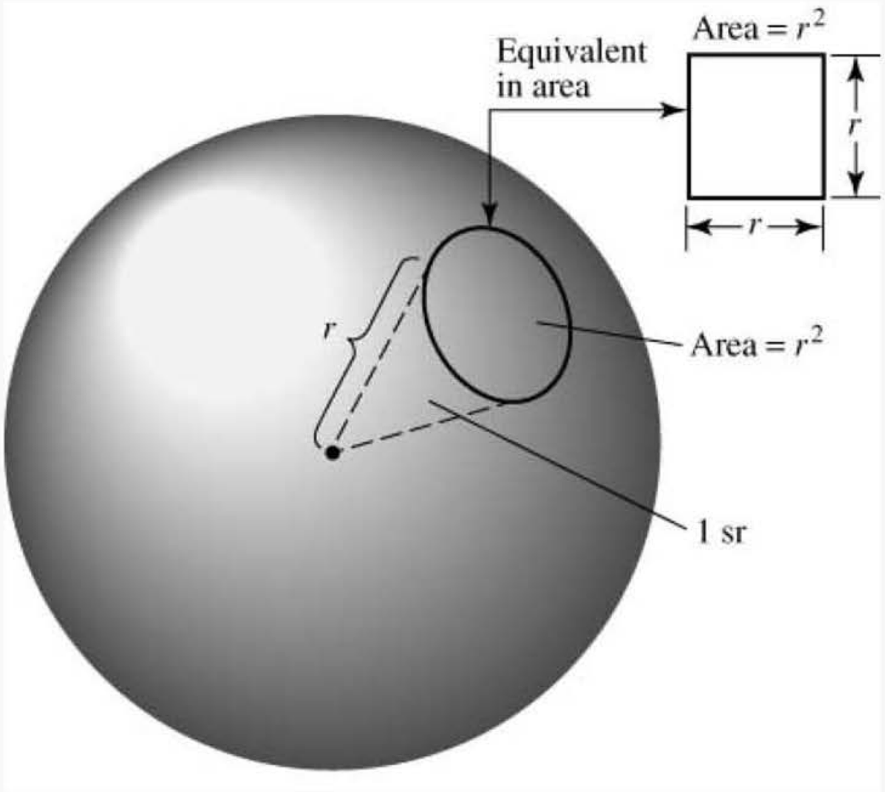
$$C = 2\pi r$$

$$\text{Rads} = \frac{C}{r} = \frac{2\pi r}{r}$$

$$\text{Rads} = 2\pi$$

Fig. 2.10(a)

Steradian



$$d\Omega = \frac{dA}{r^2} \qquad (2\text{-}1)$$

$$= \frac{r^2 \sin\theta d\theta d\phi}{r^2}$$

$$d\Omega = \sin\theta d\theta d\phi \qquad (2\text{-}2)$$

$$0 \le \theta \le \pi$$

$$0 \le \phi \le 2\pi$$

Fig. 2.10(b)

RADIATION INTENSITY

.. it is the power radiated from the antenna per unit solid angle

$$P_{rad} = \oiint U \, d\Omega = \oiint S_{rad} dA$$
$$dA = r^2 \sin\theta \, d\theta \, d\phi$$
$$\Rightarrow U = r^2 \, S_{rad}$$

Units?

Radiation intensity for an isotropic source? U_0

RADIATION INTENSITY

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$$dA = r^2 \sin\theta \, d\theta \, d\phi$$

$$\Rightarrow U = r^2 \, S_{rad}$$

$$U = \frac{r^2}{2\eta} \, |E|^2$$

Compute HPBW, FNBW

for $U_0 = \sin^3(4\theta)$

DIRECTIVITY

.. the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions.

$$D = \frac{U(\theta,\phi)}{U_o} = \frac{4\pi U(\theta,\phi)}{P_{rad}} \qquad (2\text{-}16)$$

$$D_{\max} = D_o = \frac{U_{\max}}{U_o} = \frac{4\pi U_{\max}}{P_{rad}} \qquad (2\text{-}16a)$$

$$\boxed{D(dB) = 10\log_{10}\left[D(\text{dimensionless})\right]}$$

DIRECTIVITY OF HERTZ DIPOLE

$$S_{rad} = \hat{r}\, S_r = A_0 \sin^2 \theta \,/r^2$$

So, $U = r^2 S_r = A_0 \sin^2 \theta$

Max radiation along $\theta = \frac{\pi}{2}$, so $U_{max} = A_0$

So, $P_{rad} = \oiint U \, d\Omega = A_0 \left(\frac{8\pi}{3}\right)$

Giving max directivity as $D_0 = 4\pi \frac{U_{max}}{P_{rad}} = 3/2$

In general then, directivity as a function of angle is $D = D_0 \sin^2 \theta$