Benha University **Antennas &Wave Propagation** **Electrical Eng. Dept.**
Faculty of Engineering **4th year communication**
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Sheet (2)

1. A hypothetical isotropic antenna is radiating in free-space. At a distance of 100 m from the antenna, the total electric field (E_θ) is measured to be 5 V/m. Find the
(a) Power density (W_{rad})
(b) Power radiated (P_{rad})

2. The power radiated by a lossless antenna is 10 watts. The directional characteristics of the antenna are represented by the radiation intensity of
$\mathbf{U=B_o\cos^3\theta}$ (watts/unit solid angle) ($0\le\theta\le\pi/2$, $0\le\varphi\le2\pi$)
Find the
(a) Maximum power density (in watts/square meter) at a distance of 1,000 m (assume far-field distance). Specify the angle where this occurs.
(b) Exact and approximate beam solid angle Ω_A.
(c) Directivity, exact and approximate, of the antenna (dimensionless and in dB).
(d) Gain, exact and approximate, of the antenna (dimensionless and in dB).

3. In target-search ground-mapping radars it is desirable to have echo power received from a target, of constant cross section, to be independent of its range. For one such application, the desirable radiation intensity of the antenna is given by

$$U(\theta,\phi) = \left\{\begin{matrix} 1 & 0^\circ \le \theta < 20^\circ \\ 0.342\csc(\theta) & 20^\circ \le \theta < 60^\circ \\ 0 & 60^\circ \le \theta \le 180^\circ \end{matrix}\right\} 0^\circ \le \phi \le 360^\circ$$

Find the directivity (in dB) using the exact formula.

4. The normalized radiation intensity of a given antenna is given by
(a) $\mathbf{U=\sin\theta\sin\varphi}$, **(b)** $\mathbf{U=\sin\theta\sin^2\varphi}$, **(C)** $\mathbf{U=\sin^2\theta\sin^3\varphi}$
The intensity exists only in the $0\le\theta\le\pi$, $0\le\varphi\le\pi$ region, and it is zero elsewhere. Find the
(a) Exact directivity (dimensionless and in dB).
(b) Azimuthal and elevation plane half-power beam widths (in degrees).

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5. Find the directivity (dimensionless and in dB) for the antenna of Problem 4 using Kraus' approximate formula.

6. The normalized radiation intensity of an antenna is rotationally symmetric in φ, and it is represented by

$$U = \begin{cases} 1 & 0^\circ \le \theta < 30^\circ \\ 0.5 & 30^\circ \le \theta < 60^\circ \\ 0.1 & 60^\circ \le \theta < 90^\circ \\ 0 & 90^\circ \le \theta \le 180^\circ \end{cases}$$

(a) What is the directivity (above isotropic) of the antenna (in dB)?

7. The radiation intensity of an antenna is given by
$U(\theta,\varphi)=\cos^4\theta\sin^2\varphi$, for $0\le\theta\le\pi/2$ and $0\le\varphi\le2\pi$ (i.e., inthe upper half-space). It is zero in the lower half-space.
Find the
(a) Exact directivity (dimensionless and in dB)
(b) Elevation plane half-power beam width (in degrees).

8. The far-zone electric-field intensity (array factor) of an end-fire two-element array antenna, placed along the z-axis and radiating into free-space, is given by

$$E = \cos\left[\frac{\pi}{4}(\cos\theta - 1)\right]\frac{e^{-jkr}}{r}, \qquad 0 \le \theta \le \pi$$

Find the directivity using Kraus' approximate formula

9. The normalized far-zone field pattern of an antenna is given by

$$E = \begin{cases} (\sin\theta\cos^2\phi)^{1/2} & 0 \le \theta \le \pi \text{ and } 0 \le \phi \le \pi/2,\ 3\pi/2 \le \phi \le 2\pi \\ 0 & \text{elsewhere} \end{cases}$$

Find the directivity using
(a) The exact expression
(b) Kraus' approximate formula

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10. A uniform plane wave, of is traveling in the positive z-direction. Find the polarization (linear, circular, or elliptical), sense of rotation (CW or CCW), axial ratio (AR), and tilt angle τ (in degrees) when

(a) $E_x = E_y$, $\Delta\varphi = \varphi_y - \varphi_x = 0$
(b) $E_x \neq E_y$, $\Delta\varphi = \varphi_y - \varphi_x = 0$
(c) $E_x = E_y$, $\Delta\varphi = \varphi_y - \varphi_x = \pi/2$
(d) $E_x = E_y$, $\Delta\varphi = \varphi_y - \varphi_x = -\pi/2$
(e) $E_x = E_y$, $\Delta\varphi = \varphi_y - \varphi_x = \pi/4$
(f) $E_x = E_y$, $\Delta\varphi = \varphi_y - \varphi_x = -\pi/4$
(g) $E_x = 0.5E_y$, $\Delta\varphi = \varphi_y - \varphi_x = \pi/2$
(h) $E_x = 0.5E_y$, $\Delta\varphi = \varphi_y - \varphi_x = -\pi/2$

Inall cases, justify the answer.

(REPORT)

1. The normalized radiation intensity of an antenna is symmetric, and it can be approximated by

$$U(\theta) = \begin{cases} 1 & 0^\circ \le \theta < 30^\circ \\ \dfrac{\cos(\theta)}{0.866} & 30^\circ \le \theta < 90^\circ \\ 0 & 90^\circ \le \theta \le 180^\circ \end{cases}$$

And it is independent of φ. Find the
(a) Exact directivity by integrating the function
(b) Approximate directivity using Kraus' formula.

2. Repeat Problem 8 when

$$E = \cos\left[\frac{\pi}{4}(\cos\theta + 1)\right]\frac{e^{-jkr}}{r}, \qquad 0 \le \theta \le \pi$$

Good Luck

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