Benha University **Faculty of Engineering** **Shoubra**

Antennas &Wave Propagation

Electrical Eng. Dept. **4th year communication** **2015-2016**

Sheet (2)... (2 Weeks)

1. A hypothetical isotropic antenna is radiating in free-space. At a distance of 100 m from the antenna, the total electric field ($\mathbf{E_0}$) is measured to be 5 V/m. Find the

(a) Power density (W_{rad})

(b) Power radiated (P_{rad})

2. Estimate the directivity of an antenna with $\boldsymbol{\Theta_{HP} = 2^o}$ and $\boldsymbol{\Phi_{HP}=1^o}$.

3. Find the number of square degrees in the solid angle Ω on a spherical surface that is between ($\boldsymbol{\theta=20^o}$ and $\boldsymbol{\theta=40^o}$), and ($\boldsymbol{\varphi=30^o}$ and $\boldsymbol{\varphi=70^o}$).

4. The radiation intensity of antenna is given by $\mathbf{U=B_oCos\theta}$. U exists only in the upper hemisphere, Find

a. The exact directivity.
b. The approximate directivity.
c. The decibel difference.

5. An antenna has a field pattern given by $\mathbf{E(\theta) = cos^2\theta}$, For $0\leq \theta^o \leq 90^o$. Find the beam area of this pattern.

6. The normalized field pattern of an antenna is given by $\mathbf{E(\theta)=sin\theta sin\varphi}$. $\mathbf{E_n}$ has a value only for $0\leq \theta \leq \Pi$ & $0\leq \varphi \leq \Pi$, and zero elsewhere , Find

a. The exact directivity.
b. The approximate directivity.
c. The decibel difference.

7. The power radiated by a lossless antenna is 10 watts. The directional characteristics of the antenna are represented by the radiation intensity of $\mathbf{U=B_ocos^3\theta}$ (watts/unit solid angle) ($0\leq\theta\leq\pi/2$, $0\leq\varphi\leq2\pi$)

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).

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(d) Gain, exact and approximate, of the antenna (dimensionless and in dB).

8. Calculate the $D_{approx.}$ from the HPBW of a unidirectional antenna if the power pattern is given by :

$$E(\theta,\phi) = \mathbf{30\ Cos^2\theta Sin^{3/2}\Phi}$$

$0 \le \theta \le \Pi$ $\quad\quad 0 \le \Phi \le \Pi$ and zero otherwise.

Then repeat by calculating D_{exact} for the previous pattern. Finally calculate the db difference between the exact and approximate records.

9. 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

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

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

10. The normalized radiation intensity of a given antenna is given by

(a) U=sinθsinφ, (b) U=sinθsin^{2}φ, (C) U=sin^{2}θsin^{3}φ

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).

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

12. 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)?

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13. The radiation intensity of an antenna is given by **U(θ,φ)=$\cos^4\theta \sin^2\varphi$** , for $0 \le \theta \le \pi/2$ and $0 \le \varphi \le 2\pi$ (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).

14. 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

15. 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

16. Estimate the directivity for a source with relative field pattern

a. E = $\cos 2\theta \cos\theta$. Assume a unidirectional pattern.
b. E = $\sin(\frac{\Pi}{2}\cos\theta)$. Assume $0 \le \theta \le \Pi$ & $0 \le \varphi \le 2\Pi$.

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(REPORT)

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

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

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

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

3. The normalized radiation intensity of an antenna is represented by
$U(\theta) = \cos^2(\theta)\cos^2(3\theta), \quad (0 \leq \theta \leq 90^\circ, \quad 0^\circ \leq \phi \leq 360^\circ)$
Find the exact and approximate directivity.

Good Luck

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