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1. Determine the directivity (in dB) of a power source located at the origin that radiates:

   (a) Uniformly into the upper half-space only, but nothing into the lower halfspace.

   (b) Into all space with a power density proportional to $\cos^2\theta$.

2. Evaluate the percentage of the maximum power density that is found in the direction $\theta = 45°$ for dipole antennas of overall length:

   (a) $\frac{\lambda}{4}$

   (b) $\frac{\lambda}{2}$

   (c) λ

3. A dipole antenna in free space has a linear current distribution with zero current at each end and with peak current I_0 at the center. If the length d is 0.02λ, determine the value of I_0 required to:

   (a) Provide a radiation-field amplitude of 100mV/m at a distance of 1mile, at $\theta = 90°$.

   (b) Radiate a total power of 1 Watt.

4. A monopole antenna has a length $\frac{d}{2} = 0.080$ m and may be assumed to carry a triangular current distribution, for which the feed current $I_0 = 16.0$ A at a frequency of 375 MHz in free space.

   At a point $P(r = 400 \text{ m},\ \theta = 60°,\ \phi = 45°)$, find:

   (a) $H_{\phi s}$

   (b) $E_{\theta s}$

5. For a dipole antenna of overall length $2l = \lambda$, evaluate the maximum directivity in decibels, and the half-power beamwidth.

6. Determine the necessary conditions to establish an endfire array, in which the maximum radiation is directed along the x-axis. Determine the directions (values of ϕ) for the main beams in the H-plane if the wavelength is shortened from $\lambda = 4d$ to:

   (a) $\lambda = 3d$

   (b) $\lambda = 2d$

   (c) $\lambda = d$

7. An endfire linear dipole array in which the progressive phase shift (between elements) is

$$\xi = -kd.$$

   Find the minimum element spacing d (in wavelengths) that results in *bidirectional operation*, i.e. equal intensities in the H-plane at $(a)\phi = 0, (b)\phi = \pi$

8. For a linear dipole array with element spacing $d = \lambda/4$, determine the current phase shift ξ that produces a main beam in the direction of:

$$\text{(a) } \phi = 30^\circ, \qquad \text{(b) } \phi = 45^\circ.$$

9. A short current element has $d = 0.03\lambda$. Calculate the radiation resistance that is obtained for each of the following current distributions:

   (a) **Uniform:** $I(z) = I_0$

   (b) **Linear:** $I(z) = I_0 \frac{(0.5d - |z|)}{0.5d}$

   (c) **Step:**

$$\mathrm{I(z)} = \begin{cases} I_0, & 0 < |z| < 0.25d \\ 0.5I_0, & 0.25d < |z| < 0.5d \end{cases}$$

10. A half-wave dipole antenna is known to have a maximum effective area given as $A_{\max}$.

    (a) Write the maximum directivity of this antenna in terms of $A_{\max}$ and wavelength λ.

    (b) Express the current amplitude I_0 needed to radiate total power P_r in terms of P_r, $A_{\max}$, and λ.

    (c) Determine the values of θ and ϕ for which the antenna effective area is equal to $A_{\max}$.