Problem 7.32 At microwave frequencies, the power density considered safe for human exposure is 1 (mW/cm²). A radar radiates a wave with an electric field amplitude $E$ that decays with distance as $E(R) = (3,000/R)$ (V/m), where $R$ is the distance in meters. What is the radius of the unsafe region?

Solution:

$$S_{uv} = \frac{|E(R)|^2}{2\eta_0},$$

$1$ (mW/cm²) = $10^{-3}$ W/cm² = $10$ W/m²,

$$10 = \left(\frac{3 \times 10^3}{R}\right)^2 \times \frac{1}{2 \times \frac{1}{120\pi}} = \frac{1.2 \times 10^4}{R^2},$$

$$R = \left(\frac{1.2 \times 10^4}{10}\right)^{1/2} = 34.64 \text{ m}.$$
Problem 7.26  The inner and outer conductors of a coaxial cable have radii of 0.5 cm and 1 cm, respectively. The conductors are made of copper with \( \varepsilon_r = 1 \), \( \mu_r = 1 \), and \( \sigma = 5.8 \times 10^7 \) S/m, and the outer conductor is 0.5 mm thick. At 10 MHz:

(a) Are the conductors thick enough to be considered infinitely thick as far as the flow of current through them is concerned?

(b) Determine the surface resistance \( R_s \).

(c) Determine the ac resistance per unit length of the cable.

Solution:

(a) From Eqs. (7.72) and (7.77b),

\[
\delta_s = \left[ \frac{\pi f \mu \sigma}{\varepsilon_r} \right]^{1/2} = \left[ \pi \times 10^7 \times 4\pi \times 10^{-7} \times 5.8 \times 10^7 \right]^{-1/2} = 0.021 \text{ mm}.
\]

Hence,

\[
\frac{d}{\delta_s} = \frac{0.5 \text{ mm}}{0.021 \text{ mm}} \approx 25.
\]

Hence, conductor is plenty thick.

(b) From Eq. (7.92a),

\[
R_s = \frac{1}{\sigma \delta_s} = \frac{1}{5.8 \times 10^7 \times 2.1 \times 10^{-3}} = 8.2 \times 10^{-4} \Omega.
\]

(c) From Eq. (7.96),

\[
R' = \frac{R_s}{2\pi} \left( \frac{1}{a} + \frac{1}{b} \right) = \frac{8.2 \times 10^{-4}}{2\pi} \left( \frac{1}{5 \times 10^{-3}} + \frac{1}{10^{-2}} \right) = 0.039 \text{ (\Omega/m)}.\]
Problem 7.11  A linearly polarized plane wave of the form $\mathbf{E} = \hat{x} a_e e^{-jkt}$ can be expressed as the sum of an RHC polarized wave with magnitude $a_R$, and an LHC polarized wave with magnitude $a_L$. Prove this statement by finding expressions for $a_R$ and $a_L$ in terms of $a_e$.

**Solution:**

$$\mathbf{E} = \hat{x} a_e e^{-jkt},$$

RHC wave: $\mathbf{E}_R = a_R (\hat{x} + \hat{y} e^{-jkt/2}) e^{-jkt} = a_R (\hat{x} - \hat{y}) e^{-jkt},$

LHC wave: $\mathbf{E}_L = a_L (\hat{x} + \hat{y} e^{jkt/2}) e^{-jkt} = a_L (\hat{x} + \hat{y}) e^{-jkt},$

$\mathbf{E} = \mathbf{E}_R + \mathbf{E}_L.$

$\hat{x} a_e = a_R (\hat{x} - \hat{y}) + a_L (\hat{x} + \hat{y}).$

By equating real and imaginary parts, $a_e = a_R + a_L$, 0 = $-a_R + a_L$, or $a_L = a_e/2$, $a_R = a_e/2$. 

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*Note: The solution assumes the use of vector notation and the properties of complex exponentials.*
**Problem 7.6** The electric field of a plane wave propagating in a lossless, nonmagnetic, dielectric material with \( \varepsilon_r = 2.56 \) is given by

\[
E = \hat{\phi} 20 \cos(6\pi \times 10^9 t - k z) \quad (\text{V/m})
\]

Determine:
(a) \( f, u_p, \lambda, k, \) and \( \eta \).
(b) The magnetic field \( H \).

**Solution:**

(a)
\[
\omega = 2\pi f = 6\pi \times 10^9 \text{ rad/s}, \quad f = 3 \times 10^9 \text{ Hz} = 3 \text{ GHz},
\]
\[
u_p = \frac{c}{\sqrt{\varepsilon_r}} = \frac{3 \times 10^8}{\sqrt{2.56}} = 1.875 \times 10^8 \text{ m/s},
\]
\[
\lambda = \frac{u_p}{f} = \frac{1.875 \times 10^9}{6 \times 10^9} = 3.12 \text{ cm},
\]
\[
k = \frac{2\pi}{\lambda} = \frac{2\pi}{3.12 \times 10^{-2}} = 201.4 \text{ rad/m},
\]
\[
\eta = \frac{\lambda}{\sqrt{\varepsilon_r}} = \frac{377}{\sqrt{2.56}} = 377 \sqrt{2.56} = 235.62 \Omega.
\]

(b)
\[
H = -\hat{\lambda} \frac{20}{\eta} \cos(6\pi \times 10^9 t - k z)
\]
\[
= -\hat{\lambda} \frac{20}{235.62} \cos(6\pi \times 10^9 t - 201.4 z)
\]
\[
= -\hat{\lambda} 8.49 \times 10^{-2} \cos(6\pi \times 10^9 t - 201.4 z) \quad (\text{A/m}).
\]