Two-digit number \( k \in \mathbb{V} \)

EE3140 Final Exam, Fall 2018

Circle the best answer.

1. An antenna is known to have a directive gain \( D(\theta, \phi) = 4\sin^2(\theta)\cos(\phi) \). What is the directivity of this antenna? (4 points)

\[
D = \mathcal{V}(\theta, \phi)|_{\text{max}} = 4
\]

a) 1  b) 1.5  c) 2  d) 4  e) none of the above

2. An antenna has a normalized electric field pattern \( |E| = \sin^2(\theta) \). What is the half-power beamwidth in degrees? (4 points)

\[
\sin^2\theta = 0.707
\]

\[
\theta = \sin^{-1}(\sqrt{0.707}) = 57.2^\circ
\]

\[
\text{HPBW} = 2\left(90^\circ - \theta\right)
\]

\[
\text{HPBW} = 65.5^\circ
\]

a) 78  b) 45  c) 90  d) 66  e) none of the above

3. Two identical short dipoles are located parallel to the y-axis with their centers at \( x = \pm d/2 \) where \( d = \lambda/2 \). They are driven in phase with equal frequencies and amplitudes. At what angles, \( \phi \), are the nulls (zeroes) in the electric field pattern located in the x-y plane (\( \phi \) is the angle measured from the x-axis towards the y-axis)? (4 points)

nulls @ \( \theta = 0, \pi, \pm \pi/2 \)

a) \( \phi = \pm \pi/2 \)  b) \( \phi = 0, \pi, \pm \pi/2 \)  c) \( \phi = 0, \pi \)  d) \( \phi = 0, \pi/2 \)  e) none of the above
4. A load is connected to a 50-ohm transmission line and a reflection coefficient of $\Gamma = 0.3536 + j0.3536$ is measured. What is the load impedance? (4 points)

$$Z_L = Z_0 \left( \frac{1 + \Gamma}{1 - \Gamma} \right)$$

a) 69-j65  
\(\textbf{b) 69+j65}\)  
\(\textbf{c) 50}\)  
\(\textbf{d) 25+j50}\)  
\(\textbf{e) none of the above}\)

5. Given an interface with unit normal $\hat{z}$ and $\vec{D}_2 = \hat{x} - \hat{z}$ [Coul/m²] for $z < 0$ and $\vec{D}_1 = +\hat{z}$ [Coul/m²] for $z > 0$, circle the answer below that best describes this situation: (4 points)

\[\begin{align*}
D_{n_1} - D_{n_2} &= 1 - (-1) = 2 = \epsilon_0 \\
B \text{ and } E_{z_1} &= 0 \neq E_{z_2} = \frac{1}{\epsilon_2}
\end{align*}\]

\(\therefore \text{ impossible}\)

(a) medium 1 and medium 2 are dielectrics with $\epsilon_1 > \epsilon_2$
(b) medium 1 and medium 2 are dielectrics with $\epsilon_1 < \epsilon_2$
(c) there is positive surface charge on the boundary between two dielectrics
(d) medium 2 is a perfect conductor
\(\mathbf{e) \text{ impossible}}\)

6. Given an electric field: $\vec{E} = 5 \exp^{-j4\pi \hat{x}}$ and the medium is free space. Find the frequency, $f$, in MHz and direction of propagation. (4 points)

\[\begin{align*}
k &= \frac{2\pi}{\lambda} = 4 \\
\Rightarrow \lambda &= \frac{c}{f} \\
\Rightarrow f &= \frac{4c}{2\pi} = 191 \text{ MHz}
\end{align*}\]

\(\therefore \text{ propagation}\)

\[\begin{align*}
a) 191, +\hat{y} \\
b) 8, +\hat{y} \\
c) 382, +\hat{x} \\
d) 191, +\hat{z} \\
e) \text{ none of the above}
\]