EE3140 Final Exam, Fall 2012

Note that the problems have different point values. All units are mks. Show your work for full credit. Useful constants:

\[ \varepsilon_0 = 8.854 \times 10^{-12} \text{ F/m} \]
\[ \mu_0 = 4\pi \times 10^{-7} \text{ H/m} \]

1. A uniform plane wave, traveling in the \( z \)-direction, with normal incidence to a dielectric interface has a total electric field, \( |E_{y,\text{total}}| \), as shown in the figure below.

Find the wavelength of the wave in medium 2. (4 points)

\[ \frac{\lambda}{2} = 3 \text{ m} \implies \lambda = 6 \text{ m} \]

\[ \lambda = 6 \text{ m} \]
2. A Doppler radar operating at 10GHz shows return signal at 15kHz below 10GHz. What is the speed and direction (towards or away) of the target?

\[
\Delta f = 15 \text{ kHz} = \frac{2u}{c}
\]

\[
\therefore u = \frac{2 \times 15 \text{ kHz}}{c} \text{ m/s (away)}
\]

speed (3 points) = \text{225 m/s}

direction (1 point) = \text{away}

3. A dipole in the \( z=0 \) plane is aligned with the \( z \)-axis and transmits a signal to an observer with a dipole also aligned with the \( z \)-axis and in the \( z=0 \) plane, 100m away from the transmitting dipole, and measures a signal strength of 1 \( \mu V/m \). The receiving dipole is then elevated to a new position 20 meters above its original position. What is the maximum signal, in \( \mu V/m \), that the receiving dipole will measure in this new position? (4 points)

\[
E = E_1 = \frac{C \sin \theta}{r_1^2} = \frac{100}{100^2 + 20^2} \times 0.9615 \mu V/m = 0.9615 \mu V/m
\]

\[
E = E_2 = \frac{C \sin \theta}{r_2^2} = \frac{1 \mu V}{m} \Rightarrow C_1 = 1 \mu V(100)
\]

(Note: orientation of receiving dipole to maximize received signal)

maximum signal = 0.9615 \( \mu V/m \)
4. Consider the sun rising on the eastern horizon. Let the x-axis be east, the y-axis be north and the z-axis is straight up. What polarization will the electric field have for scattered light that you receive from the north? Your answer should include both the vector direction ($\hat{x}, \hat{y}$, etc.), AND type of polarization (linear, circular, random, etc.)

\[
\text{direction} = \hat{z} \quad (2 \text{ points})
\]

\[
\text{polarization} = \text{linear} \quad (2 \text{ points})
\]
5. Two short dipoles are aligned parallel to the y-axis, but have their centers located at \( x = \pm \lambda/4 \) on the x-axis (so that they are separated by \( \lambda/2 \)). Assuming that they are driven in phase, with equal amplitudes. For the x-y plane, on the axes provided, sketch the element pattern, the array factor and the total (far-field) pattern (using pattern multiplication) (2 points for element pattern, 3 points each for array factor and total far-field). Note that the sketches must show the correct placement of the nulls, but need not otherwise be quantitatively perfect.

\[
\sin(\phi - \pi/2)
\]

Element pattern

\[
\sin \left( \frac{\pi \cos \phi}{2} \right)
\]

Array factor

\[
= \cos \left( \frac{\pi}{2} \sin \phi \right)
\]

Far-field pattern

\[
\sin(\phi - \pi/2) \cos \left( \frac{\pi}{2} \sin \phi \right)
\]

nulls @ \( 0, \frac{\pi}{2}, \pi \)