UTA PhD Diagnosis Exam (Fall 2012)

Electromagnetics

Instructions:
- Verify that your exam contains 7 pages (including the cover sheet).
- Please be sure to use blank paper to write your answers. If more space is needed, please ask the instructor for extra paper. DO NOT WRITE ON THE BACK OF A SHEET!
- The point values listed on this exam serve only as a guideline. The Dept reserves the right to make modifications to the weighting of the problems.
- Calculator is okay.

I Choose to work on Problems ____ and _____ (Choose only 2 from the 3 problems).

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Points</th>
<th>Scores</th>
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<tbody>
<tr>
<td>1</td>
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<td>2</td>
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<td>Total Score (Choose 2 Problems)</td>
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1. A plane wave propagating within an unbounded lossy medium has the form

\[ \vec{E}(x, y, z, t) = \hat{x}E_0 e^{-\alpha z} \cos(\omega t + 4x + 2y + 4z) \]

(a) Find the expression for the magnetic field, \( \vec{H}(x, y, z, t) \).
(b) Determine the time-average Poynting vector.
(c) Determine the propagation direction and wavelength.
2. This problem addresses TE mode propagation in a parallel plate waveguide with thickness $a$, as indicated in the figure below. Assume the metal plates are infinite in extent, i.e., in the $y$ and $z$ directions. The electric field in the guide is $E_y(x, z) = -A \sin(20x) e^{-j24z}$, where $x$ and $z$ are in meters. Assuming the waveguide is filled with air and operation is in the fundamental mode:
   a) Find the operating frequency.
   b) Find the dimension of the waveguide, i.e., $a$ in the figure below.
   c) Find the cutoff frequency of the waveguide.
3. For the layered medium shown below find the impedance seen by the incident wave at the point \( x = -3.75 \) cm, i.e., to the left of interface 1. The wave has a frequency of 1.5 GHz. Medium 1 is free space (intrinsic impedance of \( 120\pi \) or 377\( \Omega \), medium 2 has relative permittivity of 4, and medium 3 has relative permittivity of 8.