ECE 3065: Electromagnetics
Solutions to TEST 1 (Spring 2005)

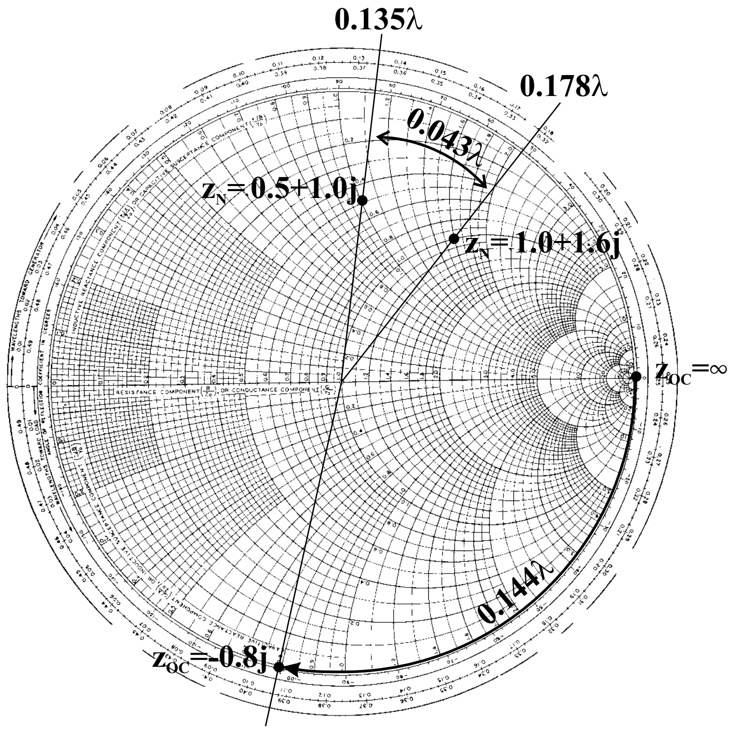
1. **Short Answer Section (20 points)**
   (a) critical
   (b) isotropic, homogeneous, source-free
   (c) $+\infty$
   (d) True
   (e) splice
   (f) inductor, capacitor, short circuit

2. **Supermarket Radio Price Tags (10 points):**

   The resistive film is clearly a conductor. If it is close enough to a PEC, then the reflection coefficient will be -1 and no power will be transmitted through the film and into the freezer. This problem has nothing to do with polarization.

3. **Tracking Tag (25 points):**

   The normalized impedance is 0.5+j and, with a 0.043λ segment of line, may be transformed into an impedance of 1+j1.6. At this point, we need to get rid of the j1.6 with the series stub. In this problem, there happens to be 2 identical stubs in series. No sweat ... just find a length that makes each open circuit transform into -j0.8 each. This distance is 0.144λ and is shown with the rest of the solution on the Smith Chart below.



It is incorrect to find the length of a single stub that produces -j1.6 and simply cut the length in half. Electromagnetically, this actually makes the magnitude of each series stub impedance much larger than 1.6!

4. **Circular-Polarized Radio Wave:** (**45 points**)

$$\tilde{\vec{\mathrm{E}}}_i(\vec{\mathrm{r}}) = \frac{377}{\sqrt{2}}(\cos\theta_i\hat{\mathrm{x}} - \sin\theta_i\hat{\mathrm{z}} + j\hat{\mathrm{y}})\exp(-j4.2[\sin\theta_i\hat{\mathrm{x}} + \cos\theta_i\hat{\mathrm{z}}]\cdot\vec{\mathrm{r}})\ \mu\mathrm{V/m}$$

(a) Wavelength from k:

$$\lambda = \frac{2\pi}{k} = 1.5\ \mathrm{m}$$

(b) Brewster angle for water ($\epsilon_r = 81$):

$$\theta = \sin^{-1}\frac{1}{\sqrt{1+\frac{1}{81}}} = 83.7^\circ$$

(c) Incident magnetic field:

$$\tilde{\vec{\mathrm{H}}}_i(\vec{\mathrm{r}}) = \frac{1}{\sqrt{2}}(j\cos\theta_i\hat{\mathrm{x}} + \hat{\mathrm{y}} - j\sin\theta_i\hat{\mathrm{z}})\exp(-j4.2[\sin\theta_i\hat{\mathrm{x}} + \cos\theta_i\hat{\mathrm{z}}]\cdot\vec{\mathrm{r}})\ \mu\mathrm{A/m}$$

(d) Angle-of-Arrival coordinates:

$$\theta = 6.3^\circ \qquad \varphi = 180^\circ$$

(e) Keeping in mind that there is no $\|$ reflection for the Brewster angle,

$$\tilde{\vec{\mathrm{E}}}_r(\vec{\mathrm{r}}) = j\Gamma_\perp\frac{377}{\sqrt{2}}\hat{\mathrm{y}}\exp(-j4.2[\sin\theta_i\hat{\mathrm{x}} - \cos\theta_i\hat{\mathrm{z}}]\cdot\vec{\mathrm{r}})\ \mu\mathrm{V/m}$$