Homework 1: EEL760 Antenna Theory & Design

Notes: (1) Released to class: 05.07.2015. Due on: 5pm 13.07.2015 in my dept. mailbox. 10% penalty of max marks for each day of delay.
(2) You are free to discuss with your friends and look at course material. But, the submitted work should be entirely original. On the cover sheet, please mention who you discussed the problem set with. Don't worry, there are no negative points for discussing the problems! But remember the distinction between discussing and copying – the former is welcome, the latter results in an instant fail!
(3) State all intermediate steps clearly, making reasonable assumptions as you go along. The solution should be self-contained and should make sense to any general scientist reading it. If you need to get any additional information to solve the problem, be sure to add a reference.
(4) Please write neatly. If you can submit a LaTeX typed document, even better!

Problem 1 Take any modern technology that you find interesting. Create a flow chart that shows how the current technology has evolved from key experimental and theoretical breakthroughs in the past. You should go to sufficient depth and reach some very basic starting point.

Problem 2 Show that $\vec{\mathcal{E}}(x,t) \times \vec{\mathcal{H}}(x,t)$ (instantaneous vectors) corresponds to power flow using basic ideas from vector calculus and Maxwell's equations. Clearly state which theorems are used and interpret all the terms physically.

Problem 3 In class we derived a vector wave equation for $\vec{A}$ given a electric current source, $\vec{J}$. Now consider the case when $\vec{J} = 0$, but $\vec{M} \neq 0$, i.e. a non-zero magnetic current source. How will we derive E, H in this case? Propose some different vector potential and derive a new vector wave equation for this potential.
Hint: Will there be any electric charge if $J = 0$? Use this, and the logic of the A-equation to get a new equation. Remember, derive the new equation, don't solve it.

Problem 4 Consider a spherical shell of radius R carrying a uniform surface charge σ, spinning at an angular velocity $\vec{\omega}$. Find the magnetic field produced at some point $\vec{r}$ (both cases, inside and outside the shell).
Hints: For ease of derivation, place your observer point $\vec{r}$ along the z axis, and let the rotation axis be oriented arbitrarily. The velocity of any point $\vec{r'}$ on the sphere is given by $\vec{\omega} \times \vec{r'}$; use this to derive the current as we had done with the sheet charge problem in class, and then to calculate $\vec{A}$. Comment on the physical significance of the results.

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