

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science

Problem Set No. 4
Spring Term 2008

6.632 Electromagnetic Wave Theory

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Due: 03/06/2008 R

Reading assignment: Section 4.1, 4.2 ; J. A. Kong, “*Electromagnetic Wave Theory,*” EMW Publishing, 2005.

Problem P4.1

Let a plane wave be incident on a plane boundary from the inside of a negative uniaxial crystal. Consider the special case in which the optic axis is perpendicular to the plane of incidence. Find the range of θ such that there is only total internal reflection for the ordinary wave and the transmitted waves are extraordinary waves.

Problem P4.2

Consider a solid-state Fabry-Perot etalon filter made of an eight-layer stratified medium. Regions 1, 3, 5, and 7 are made of magnesium fluoride (refractive index $n = 1.35$) and are a quarter-wavelength thick. Regions 2, 4, and 6 are made of zinc sulfide (refractive index $n = 2.3$). Regions 2 and 6 are a quarter-wavelength thick, but region 4 is a half-wavelength thick. What are the reflectivity and transmissivity for a plane wave normally incident upon this stratified medium? Explain why the structure can be used for filtering purposes. (You are allowed to use mathematical software to solve this problem)

Problem P4.3

Consider a cylindrical wave $H_0^{(1)}(k_\rho \rho) e^{ik_z z}$ with frequency 3 GHz propagating in a dielectric medium with $\epsilon = 2\epsilon_o$ and $\mu = \mu_o$.

- If $k_z = 0$, what is k_ρ ? Use Matlab to plot this wave $H_0^{(1)}(k_\rho \rho)$ in $x-z$ plane. (Hint: use the functions “besselh” and “pcolor” in Matlab.)
- If the angle between \bar{k} and the horizon is 30 degree, what is k_z ? What is k_ρ ? Use Matlab to plot this wave $H_0^{(1)}(k_\rho \rho) e^{ik_z z}$ in $x-z$ plane.
- If a charge is moving along z axis with the speed $v = 0.9c$, Cerenkov radiation will occur. The radiation can be decomposed into a spectrum of cylindrical waves. Download “cerenkov.m” from <http://cetaweb.mit.edu/6.632/cerenkov.m> to see the effect. Note that the current position of this charge is at $z = 0.5$. Describe the phenomenon and hand in the plot.