

Electrodynamics
Midterm Exam
May 11, 2005

Problem 1:

- (a) If we construct a rectangular microwave wave guide out of a perfect conductor that is .5 cm x 1 cm on a side, what is the lowest frequency that can propagate down the guide?
- (b) If we put a signal generator at the end of the guide that generates only the lowest mode and run that generator at twice the cut-off frequency of that mode, what are the phase velocity and the group velocity of that wave?
- (c) If the signal generator were run at only $\frac{1}{2}$ the cut-off frequency, find the transverse electric field as a function of distance down the wave guide and time.

Problem 2:

The picture of a metal that we developed in class gives the electric susceptibility as

$$\varepsilon(\omega) = \varepsilon_0 - \varepsilon' \left(\frac{1}{\omega^2 + \gamma^2} \right) + i \frac{\varepsilon''}{\omega} \left(\frac{\gamma}{\omega^2 + \gamma^2} \right)$$

where all of the constants are real.

- (a) How must ε' be related to ε'' to satisfy the Kramers-Kronig relationships?
- (b) For a specific angular frequency ω , we can write the susceptibility as $\varepsilon = \varepsilon_R + i\varepsilon_I$. If our metal has a magnetic permeability of μ_0 and a transverse magnetic wave of angular frequency ω is incident on a conductor at an angle θ , what percentage of the incident power is absorbed by the conductor? (In this problem, I am not interested in an algebraic answer. Please the steps you would take to find the answer and put down the relevant equations that you would use along the way.)