METU Electrical-Electronics Engineering Department, 2020-2021 Fall Semester

EE303 Homework #6

Due Date/Time: *December 14, 2020 Monday, 1:00 pm*

Please upload your solutions to ODTUClass next Monday no later than 1:00 pm.

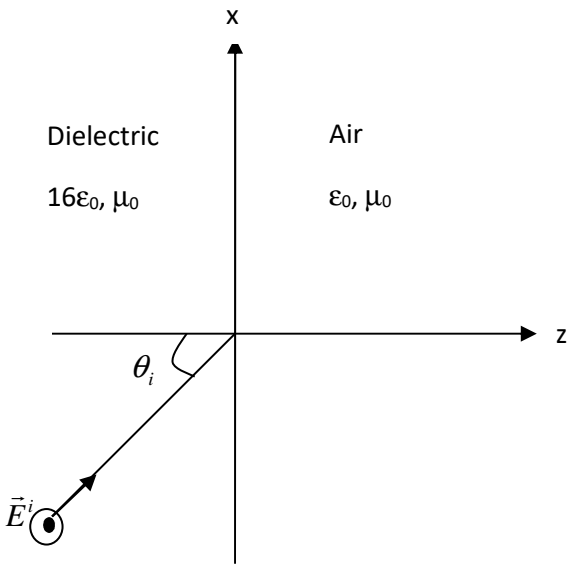
If you have questions/comments about this Homework Assignment, please send your e-mails to

Prof. Dr. Gönül Turhan-Sayan at gtsayan@metu.edu.tr

Course Ethics: In all activities (homeworks, quizzes, exams, attendance questionnaire) of the course, students should not receive any unauthorized help from other students or persons. All submissions must be students' own work. Students are assumed to understand what constitutes plagiarism, cheating, and other unethical activities.

Question 1

A uniform plane wave of angular frequency ω is incident from a lossless dielectric medium of parameters $\varepsilon_1 = 16\varepsilon_0$, $\mu_1 = \mu_0$ onto air as shown in the figure. The angle of incidence is $\theta_i = 30°$, and the incident electric field is polarized in y-direction, the peak value of $\vec{E}^i$ being 10 V/m.



a) Using Snell's Law etc. determine the values of $\sin\theta_t$ and $\cos\theta_t$, where θ_t is the angle of transmission (you don't need to determine the value of θ_t itself to solve this problem). Comment on your result.

b) Compute the reflection and transmission coefficients.

c) Write down the expression for the phasor electric field intensity $\vec{E}^r(x,y,z)$ of the reflected wave. ($\vec{E}^r$ must be expressed as an explicit function of x, y, z and should not contain any unknowns. Leave the angular frequency ω as ω.)

d) Write down the expression for the time domain $\vec{E}^r(x,y,z,t)$ of the reflected wave.

e) Write down the expression for the phasor electric field intensity $\vec{E}^t(x,y,z)$ of the transmitted wave.

f) Write down the expression for the time domain $\vec{E}^t(x,y,z,t)$ of the transmitted wave.

g) Is the transmitted wave a uniform plane wave? Support your answer.

h) Determine the phase velocity of the transmitted wave. Comment on the result, knowing that this wave exists in air.

Question 2

In memory of Prof. <u>Fatih Canatan</u> who contributed so much to the electromagnetics education of our department: The following problem was prepared by him many years ago, as an exam question.

Please explain your answers, and show all details of your calculations.
(Warning : Graphs are not scaled properly)

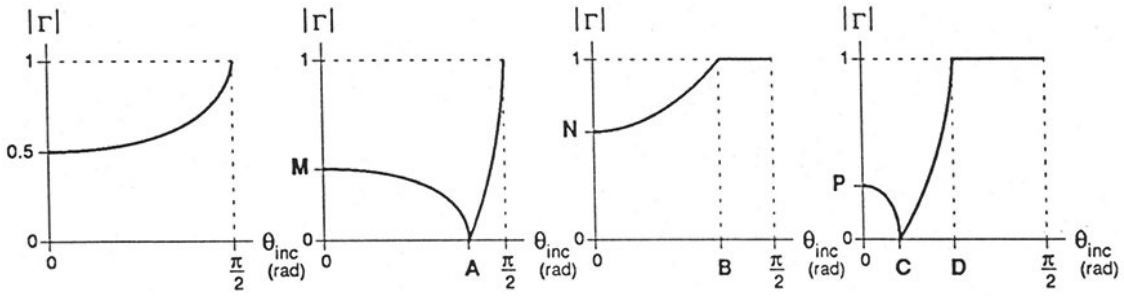


Fig. 1 Fig. 2 Fig. 3 Fig. 4

TiO_2 and Quartz have the same permeability $\mu = \mu_0$ but the permittivity of TiO_2 is greater. Consider a planar interface of TiO_2 and Quartz which is illuminated by a linearly polarized plane electromagnetic wave. Rough plots of $|\Gamma|$ versus angle of incidence, where Γ is the reflection coefficient, are given in the figures shown above. The figures cover incidence through both media and show both types of polarization (E $\perp$ and // to POI, the plane of incidence). Unfortunately, we don't know which figure was for which case since the labels are forgotten ☺

Fill in the missing statements and values in the following:

a) Incident wave is in TiO_2 and E $\perp$ POI in Figure ____

b) Incident wave is in TiO_2 and E //POI in Figure ____

c) Incident wave is in Quartz and E $\perp$ POI in Figure ____

d) Angle A is called ____

e) Angle B is called ____

f) The value of M is ____

g) The value of N is ____

h) The value of P is ____

i) The value of the angle A is ____

j) The value of the angle B is

k) The value of the angle C is

l) The value of the angle D is

m) If the wavelength in TiO_2 is 1mm, the value of the wavelength in Quartz is

Problem 3. (Reading Assignment Problem**)**

Define the Brewster Angle and derive the expression for the Brewster Angle for the Parallel Polarization case. Simplify the expression you obtained for the case when both media are nonmagnetic.