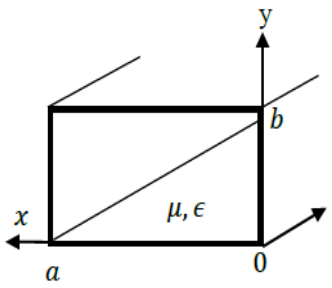
Middle East Technical University
Department of Electrical Electronics Engineering
2020-2021 Fall Semester

EE 303 Electromagnetic Waves - Homework # 10

Due: *Please submit your solutions by* ***January 11, 2021 Monday before 1:00 p.m.*** *at the ODTUClass.*



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.*

- *You may direct your questions/remarks about EE303 Homework #10 to Prof. Gönül Turhan Sayan at gtsayan@metu.edu.tr*
- ***Assume*** *a uniform cross-section waveguide extending along the z-direction that is filled by a simple and lossless material. Please use the problem geometry shown in the figure while solving the questions given in this homework:*

Q.1 A rectangular waveguide with dimensions a = 4 cm and b = 3 cm is given. Consider a TM mode with axial phasor electric field component $E_z = E_0 \sin\left(\frac{2\pi x}{a}\right) \sin\left(\frac{3\pi y}{b}\right) e^{-\gamma z}$

a) Assume that the waveguide is filled with air and the frequency is f = 18 GHz. Find the propagation constant γ. Is this a propagating mode or an evanescent mode? Explain.
b) If this waveguide is filled with a lossless dielectric material with parameters $\varepsilon = \varepsilon_0 \varepsilon_r$, $\mu = \mu_0$, what should be the range of values of ε_r so that the given mode is a propagating mode at f = 6 GHz?

Q.2 An air-filled waveguide of dimensions a = 3 cm and b = 1.5 cm supports a waveguide mode field at frequency f = 13 GHz with the axial magnetic field phasor $H_z(x, y, z) = \cos\left(\frac{\pi x}{a}\right) e^{-\gamma z}$.

a) Which waveguide mode is this?
b) Find the cut-off frequency f_c of this mode.
c) Calculate the propagation constant γ of this mode.
d) What is the wavelength of this mode in the guide?
e) What is the phase velocity in the guide? Compare it to the speed of light in free space.
f) Calculate wave impedance of this mode.
g) If the frequency is changed to f = 3 GHz, calculate the new values for the propagation constant and the wave impedance. Make a comment on the results.

Q.3 (Reading Assignment Question) Give the general expressions of wave impedance (Z) for the TE and TM modes of a rectangular waveguide in terms of the cut-off frequency f_c and the operation frequency f for (i) propagating modes and (ii) evanescent (non-propagating) modes. What is the implication of having a purely imaginary value or a purely real value for the wave impedance for a given mode? Comment on the expressions.