THE UNIVERSITY OF BRITISH COLUMBIA
Department of Electrical and Computer Engineering

ELEC 311 – Electromagnetic Fields and Waves
2025 W1

Practice Final Exam 3

Read the entire question before answering. Answers should be short and to the point. ***Use sketches to explain your solution as required****. Clarity, conciseness, and presentation all count. Solution = Intuition (strategy) + Execution (calculation). Numerical answers should include the symbol, quantity, and units, e.g.,* $\boldsymbol{\alpha = 5\ Np/m}$*, and be inserted within the large square brackets. The actual exam will be printed on tabloid-size paper.*

1. Maxwell's Equations [25]

Given that $\mathrm{E} = \mathrm{E}_0 \cos(\omega t + \beta x)\ \hat{\mathbf{z}}$ in free space.

a. [10] Find **H**.

[ ]

b. [5] Find **D** and **B**.

[ ]

[ ]

c. [5] In what direction is the wave propagating?

[ ]

d. [5] Sketch *E* and *H* at $t = 0$.

2. Transmission Lines [25]

Measurements are made at 5 kHz on a 0.5-mile-long transmission line. The results show that the characteristic impedance of the line is $94 \measuredangle -23.2°\ \Omega$, the total attenuation is 0.06 Np, and the phase shift between the input and output is 8°.

a. [10] Find the *R, L, C,* and *G* values per mile for the line:

$$\begin{bmatrix} & \\ & \\ & \\ & \end{bmatrix}$$

b. [5] Find α and β:

$$\begin{bmatrix} & \\ & \end{bmatrix}$$

c. [5] Find *Z* and *Y*:

$$\begin{bmatrix} & \\ & \end{bmatrix}$$

d. [5] Find the wavelength and phase velocity on the line:

$$\begin{bmatrix} & \\ & \end{bmatrix}$$

Find the power lost when 3 Watts is applied to the input and the line is terminated by a matched load

$$\begin{bmatrix} & \end{bmatrix}$$

3. Electromagnetic Waves [25]

An electromagnetic plane wave with a frequency of 10 GHz is normally incident on a dielectric layer with unknown relative permittivity that is laying atop a second dielectric with relative permittivity = 4.

a. [5] Find the wavelength in free space and in the second dielectric.

[ ]
[ ]

b. [5] What are the boundary conditions that must be applied at the front and rear surfaces of the dielectric layer? What boundary conditions can be ignored in this case?

[ ]

[ ]

c. [5] What should the thickness and permittivity of the dielectric layer be to eliminate reflections from the front face?

[ ]
[ ]

d. [5] What will be the VSWR in free space, the dielectric layer, and the second dielectric?

[ ]
[ ]
[ ]

e. [5] What will be the velocity of propagation in free space, the dielectric layer, and the second dielectric?

[ ]
[ ]
[ ]

4. Waveguides [25]

Consider an air-filled parallel-plate waveguide whose width, *b,* is much greater than the separation between plates, *d*.

a. [5] Sketch a parallel plate waveguide and show the direction of the electric and magnetic field vectors of a wave propagating in the TEM mode, also known as the TM_0 mode. Explain why the TE_0 mode cannot exist.

b. [5] Sketch the relationship between k, k_c and k_z in a parallel plate waveguide. Indicate θ_m.

c. [5] What separation, *d,* is required for the $m = 1$ mode to have a group velocity $v_g = 0$ at a frequency of 1 GHz? What condition is said to occur when $v_g = 0$?

[ ]

[ ]

d. If the separation between plates is $d = 30$ cm,

i) [5] Calculate the cutoff frequencies of the first few TE & TM modes. How many TE and TM modes will propagate at 2 GHz? List them.

ii) [5] What is the highest frequency at which *only* the TEM mode will propagate if $d = 30$ cm?

[ ]