THE UNIVERSITY OF BRITISH COLUMBIA
Department of Electrical and Computer Engineering

ELEC 311 – Electromagnetic Fields and Waves
2025 W1

Practice Final Exam 2

*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., $\alpha = 5\,Np/m$, and be inserted within the large square brackets. The actual exam will be printed on tabloid-size paper.*

1. Transmission Lines [25]

A rigid coaxial line used in a transmitter operating at 3 GHz is fabricated from annealed copper with $\sigma = 5.8 \times 10^7$ S/m and has an air dielectric. The diameter of the outer shell is 7/8-inch. The thickness of the outer shell is 0.032 inch. The diameter of the inner conductor is 0.375 inch.

a. [10] Determine the per-metre values of *L, C, G,* and *R* for the line.

[   ]

[   ]

[   ]

[   ]

b. [10] Determine the characteristic impedance and propagation constant.

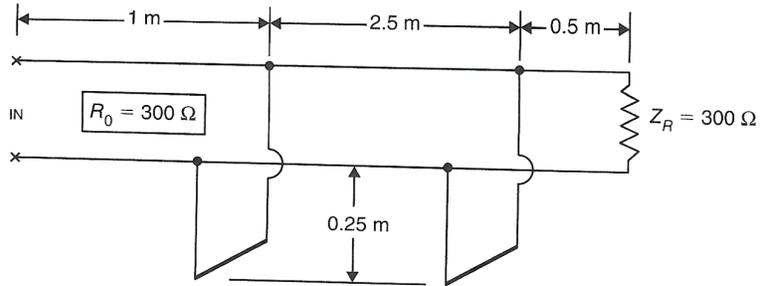[   ]

c. [5] Determine the wavelength and velocity of propagation.

[   ]

[   ]

2. Smith Charts and Stubs [25]

A 4-m long, stub-supported, lossless, air-dielectric line has a characteristic impedance of 300 Ω and is driven by a 300 MHz source. As depicted in the figure below, it is terminated by a 300-Ω resistive load and supported by shorted quarter-wave stubs.

With no changes in the physical dimensions, the line is then operated at 400 MHz instead. For this new mode of operation:

a. [15] Use a Smith Chart to find the VSWR on each of the three sections of the line:

[   ]

[   ]

[   ]

b. [5] Use a Smith Chart to find the VSWR on the support stubs:

[   ]

[   ]

c. [5] Use a Smith Chart to find the input impedance of the line:

[   ]

[   ]

3. Electromagnetic Waves [25]

An electromagnetic plane wave with a frequency of 10 GHz is normally incident on a dielectric slab of thickness t with relative permittivity $= 2$.

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

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$$\left[\right]$$

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

$$\left[\right]$$

$$\left[\right]$$

c. [5] What should the thickness of the slab be to eliminate reflections from the front face?

$$\left[\right]$$

d. [5] What will be the VSWR in the slab?

$$\left[\right]$$

e. [5] What will be the velocity of propagation in free space and in the slab?

$$\left[\right]$$

$$\left[\right]$$

4. Oblique Incidence [25]

An electromagnetic wave propagates from free space toward the face of a dielectric material. The angle of incidence is 75 degrees. A researcher uses a measurement apparatus to show that the reflected wave is linearly polarized regardless of the polarization of the wave.

a. [5] Find the angle of reflection.

[   ]

b. [5] Find the angle of transmission (or refraction).

[   ]

c. [5] Find the relative permittivity of the dielectric.

[   ]

d. [5] What is the polarization of the reflected wave?

[   ]

e. [5] Sketch the problem scenario and indicate the relevant material media, waves, and directions: