EE 101B
Spring 2020
Final Exam
Wednesday, 10 June, 2020

Name: _____

Student ID Number: _____

Honor Pledge:

"I have neither given nor received aid on this examination, nor have I concealed any violation of the Honor Code."

Date: _____ Signature: _____

Problem 1: (20 Points)

Consider a hollow rectangular metallic waveguide with cross-section dimensions of a =1/3 cm and b =1/4 cm.

(a) List the guided TE modes through this waveguide at an operating frequency of 85 GHz?
(b) Determine the group velocity, phase velocity, propagation constant, and wave impedance of a 50 GHz wave propagating along this waveguide.
(c) For the lowest order TE mode with a cutoff frequency above 85 GHz, how far can the wave travel before its electric field amplitude drops by a factor of 1/*e* at 85 GHz?

Problem 2: (20 Points)

(a) Find the far-field (R >> λ) radiation average power density, total radiated power, directivity and effective area of an antenna with a radiation field of

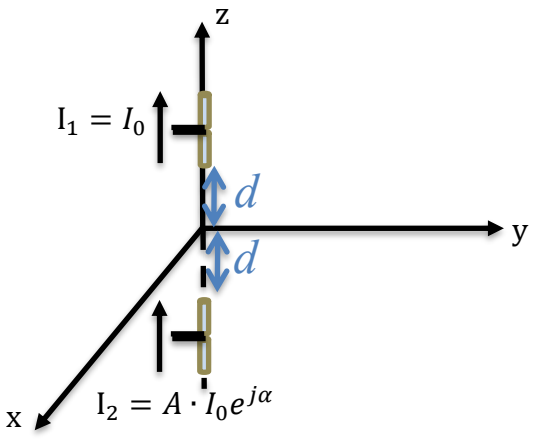
$$E = \begin{cases} (\sin\theta \cos^2\phi)^{1/2} & 0 \le \theta \le \pi \text{ and } 0 \le \phi \le \pi/2, 3\pi/2 \le \phi \le 2\pi \\ 0 & \text{elsewhere} \end{cases}$$

(b) Find the elevation plane and azimuth plane half-power beam widths (in degrees).

Problem 3: (30 Points)

Two Hertzian dipole antennas placed along the *z*-axis are fed by the currents $I_1 = I_0$ and $I_2 = A \cdot I_0 e^{j\alpha}$, where *A* is a constant.

(a) Find the expressions for the electric field, magnetic field, and average power density radiated by the antennas in far field as a function of θ, ϕ, and R. Use *k* as the wavenumber of the radiated electromagnetic wave.
(b) Find the received power by a half-wave dipole antenna places along the y-axis at a distance R (R >> λ).
(c) What is the minimum distance *d* so that radiation nulls (regions with no radiation) are found at angles θ = 0° and θ = 60°?



Problem 4: (10 Points)

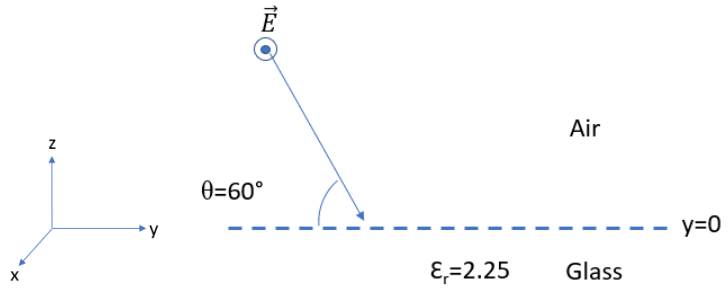
The magnetic field of a uniform plane wave propagating in a lossless simple nonmagnetic medium ($\mu = \mu_0$) is given by

$$\vec{B}(x,t) = \hat{y}\frac{1}{4}\sin[2\pi(10^8 t + 0.5x - 0.125)] \qquad \mu T$$

(a) Determine the frequency, wavelength and the phase velocity.
(b) Determine the relative permittivity and the intrinsic impedance of the medium.
(c) Find the corresponding $\vec{E}$.
(d) Find the time-average power density carried by this wave.

Problem 5: (20 Points)

A 30 GHz TE-polarized wave travelling in air is incident on an infinitely thick glass surface as shown below. The wave has a power density of 2 W/cm^2.



(a) Find phasor expressions for the incident electric field and magnetic field.
(b) Find phasor expressions for the reflected and transmitted electric field and magnetic field.