Mid-term Examination (EP3110) 25-09-2021 Max. Marks: 30

Time: 11:00 hrs to 12:30 hrs Duration: 1.5 hours

[Instructions: 1. Write your name and roll number in your answer sheet.
2. Use the following values if needed $\mu_o = 4\pi x10^{-7}$ H/m, $\varepsilon_o = 8.84 \times 10^{-12}$ F/m, c = 3 x 10^8 m/s.
3. Unless it is specified consider $\mu = \mu_o$. All the quantities mentioned here stand the usual meaning.
4. Upload the copy of the answer sheet (in pdf format) in moodle]

1. Consider a uniform plane wave propagating in the +y direction in air whose magnetic field is $\vec{H} = \hat{z}\, 4 \times 10^{-6} \cos\left(10^7 \pi t - k_o y + \frac{\pi}{4}\right)$ A/m. a) Then determine k_o and the location where H_z vanishes at t = 3 milliseconds. b) Also write the instantaneous expression for the electric field. [3 marks]

2. A *y*-polarized uniform plane wave at frequency 3 GHz propagates in the +*x* direction in a nonmagnetic medium having a dielectric constant 25 and a loss tangent 10^{-2}. a) Determine the distance over which the amplitude of the propagating wave will be cut into half. b) Determine the intrinsic impedance, wavelength, the phase velocity and the group velocity of the wave in the medium. [5 marks]

3. If the electric field intensity of a uniform plane wave propagating in *y*-direction in a dielectric medium having $\mu = \mu_o, and\ \varepsilon = \varepsilon_o \varepsilon_r$ is given by $\vec{E}(y,t) = 377\cos(10^9 t - 5y)\hat{z}$ V/m, then determine the dielectric constant of the medium and the phase velocity of the wave. [3 marks]

4. If an electromagnetic wave of frequency 1 kHz and electric field strength of 1 V/m pass through the sea whose conductivity $\sigma = 4\ \Omega^{-1}m^{-1}$, $\varepsilon_r = 80$. What is the depth of the sea at which the electric field is 1 μV/m. [3 marks]

5. The electric field of an elliptically polarized wave traveling in the positive *z*-direction in free space are $E_x = 3\cos(\omega t - \beta z)$ V/m and $E_y = 6\cos\left(\omega t - \beta x - \frac{\pi}{3}\right)$ V/m. Calculate the average power per unit area carried by the wave. [3 marks]

6. Consider a linearly polarized plane wave making an oblique incidence at $\theta_i = 45^o$ when it travels from distilled water ($\mu_r = 1, \varepsilon_r = 81$ and $\sigma = 0$) to free space (air). Find out the magnitude of the electric field in air along the interface direction. [4 marks]

7. A uniform plane wave propagating in free space with electric field $377e^{-j0.8662z}e^{-j0.5y}\hat{x}$ V/m strikes a dielectric medium ($\mu = \mu_o, \varepsilon_r = 9$) at 30° with respect to the normal to the plane interface. Determine a) frequency of the wave, b) expression for electric and magnetic field in both media and c) the average power density of the wave in the dielectric medium. [5 marks]

8. Consider a solid ferrite-titanate slab of thickness d = 10 mm, $\mu_r = \varepsilon_r = 60(2 - j1)$. The slab is backed by a flat conducting sheet as shown in the figure. If a plane wave of frequency 100 MHz be incident normally on this slab, how much is the reflected wave attenuated with respect to the incident wave? (Assume σ = 0 for the medium). [4 marks]