KATHMANDU UNIVERSITY
End Semester Examination [C]
April/May, 2023

May-28, 2023

Level : B.E.
Year : II
Time : 2 hrs. 30 mins.

Course : EEEG 309
Semester : I
F.M. : 40

SECTION "B"
[5 Q. × 8 = 40 marks]

Attempt *ANY FIVE* questions. Use constants and relations provided if needed. Assume suitable values for missing parameters if any.

1. a. Explain spherical co-ordinate system with relevant figures and expressions. [2]

   b. Electric field intensity due to an unknown charge configuration at a point in space using cylindrical coordinates is given as
   $\boldsymbol{E} = z\sin\phi\ \boldsymbol{a}_\rho + 3\rho\cos\phi\ \boldsymbol{a}_\phi + \rho\ \cos\phi\ \sin\phi\ \boldsymbol{a}_z$.
   Convert the field expression to Cartesian (rectangular) co-ordinates. Also find the field vector at point $P(x = 1, y = 1, z = 1)$. [3]

   c. Two positive point charges each of magnitude $Q_1 = Q_2 = 2\ \mu C$ are located on xy plane along y axis at points $y = \pm 2\ m$. Find the electric field intensity due to the charges at $P_1(4,0,0)$. Consider that the medium is air. [3]

2. a. Electric flux density at some space is $\boldsymbol{D} = 0.3r^2\mathbf{a}_r$ nC/m$^2$. Find electric field intensity $\boldsymbol{E}$ at point $\boldsymbol{P}$ (r=2, θ=25°, ϕ=90°). If we construct a closed sphere with center at origin and radius r=3, use Gauss's theorem to find the total charge within the sphere? [3]

   b. Define electric potential and potential difference. How is it related to the electric field intensity? [2]

   c. State Maxwell's equation for static and time varying fields in integral and point forms. [3]

3. a. A 9.4 GHz uniform plane wave is propagating in a medium with $\varepsilon_r = 2.25$ and $\mu_r = 1$. If the magnetic field intensity is 7 mA/m and the material is loss less, find [4]
   i) Velocity of propagation ii) The wave length iii) Phase constant iv) Intrinsic impedance v) Magnitude of electric field intensity

   b. What do you understand by 'uniform plane wave'? Starting from Maxwell's equations, derive the expressions for field components of a uniform plan wave travelling in the perfect dielectric medium [4]

4. a. Explain the propagation characteristics when uniform plane wave travel in free space, perfect dielectrics and good conductors. [2]

   b. A lossless transmission line with $Z_0 = 50\ \Omega$ is 30m long and operates at 2 MHz. The line is terminated with a load $Z_L = 60 + j\,40\ \Omega$ . If velocity is $v = 3 \times 10^8\ m/s$ on the line, find (a) the reflection coefficient, (b) the standing wave ratio and the input impedance. [4]

   c. What do you understand by voltage standing wave ratio? What is its importance in transmission lines? [2]

5. a. Explain in brief the modes supported by rectangular waveguides. Consider a rectangular waveguide with $\varepsilon_r = 2$, $\mu_r = \mu_0$ with dimensions $a = 1.07\ cm$, $b = 0.43\ cm$. Find the cut off frequency for $TM_{11}$ mode and the dominant mode. [3]

b. Explain impedance matching in transmission lines using quarter wave transformer and single stub. [3]

c. What is pointing vector? Why is it important in field of electromagnetics? [2]

7. a. A load of $100 + j150\ \Omega$ is connected to a $75\ \Omega$ lossless line. Find using Smith Chart: [3]

i) reflection coefficient

ii) VSWR

iii) load admittance

iv) In put impedance at $0.4\ \lambda$ from the load.

b. What do you understand by the cutoff frequency in waveguides? Derive the expression for cutoff frequency and wavelengths for a parallel plate waveguide. [3]

c. Explain the boundary condition for electric field and magnetic fields at conductor air boundary. [2]

**Some useful constants and relations:**

$\varepsilon_0 = 8.85 \times 10^{-12} F/m$

$\mu_0 = 4\pi \times 10^{-7} H/m$

Relation between vectors in cylindrical and Cartesian coordinates

$$\begin{bmatrix} A_\rho \\ A_\phi \\ A_z \end{bmatrix} = \begin{bmatrix} \cos\phi & \sin\phi & 0 \\ -\sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} A_x \\ A_y \\ A_z \end{bmatrix} \qquad \begin{bmatrix} A_x \\ A_y \\ A_z \end{bmatrix} = \begin{bmatrix} \cos\phi & -\sin\phi & 0 \\ \sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} A_\rho \\ A_\phi \\ A_z \end{bmatrix}$$

| | $\mathbf{a}_\rho$ | $\mathbf{a}_\phi$ | $\mathbf{a}_z$ |
|---|---|---|---|
| $\mathbf{a}_x \cdot$ | $\cos\phi$ | $-\sin\phi$ | 0 |
| $\mathbf{a}_y \cdot$ | $\sin\phi$ | $\cos\phi$ | 0 |
| $\mathbf{a}_z \cdot$ | 0 | 0 | 1 |

$\rho = \sqrt{x^2 + y^2}$

$x = \rho \cos\phi$

$y = \rho \sin\phi$ $\qquad z = z$

For a transmission line:

$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}} \qquad \sqrt{(R + j\omega L)(G + j\omega C)} = \sqrt{ZY} = \alpha + j\beta$$

For parallel plate waveguides

$$\omega_{cm} = \frac{m\pi c}{nd} \qquad \beta_m = \frac{n\omega}{c}\sqrt{1 - \left(\frac{\omega_{cm}}{\omega}\right)^2} \qquad \lambda_{cm} = \frac{2\pi c}{\omega_{cm}} = \frac{2nd}{m}$$