EM THEORY & TRANSMISSION LINES
(ECEN 2203)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Solution of propagating wave equation
(a) $f(x,y,t) = f(x)f(y)e^{j\omega t}$ (b) $e^{j(\omega t \pm \beta z)}$
(c) $\sin(\omega t)\cos(\beta z)$ (d) only (a) and (b).

(ii) The value of electric field at dielectric-metal interface always
(a) 1 (b) 1/2
(c) 0 (d) depends upon the magnetic field.

(iii) The boundary condition on **E** is
(a) $\mathbf{a}_n \times (\mathbf{E}_1 - \mathbf{E}_2) = 0$ (b) $\mathbf{E}_1 = \mathbf{E}_2$
(c) $\mathbf{a}_n \cdot (\mathbf{E}_1 - \mathbf{E}_2) = 0$ (d) $\mathbf{E}_1 - \mathbf{E}_2 = \varepsilon_1 - \varepsilon_2$

(iv) Initial amplitude of electric field in certain medium decreases at a rate of 5 Np/m. The attenuation constant of the medium is.
(a) 2.5 Np/m (b) 5 Np/m
(c) 10 Np/m (d) 1 Np/m

(v) Choose the characteristic impedance expression for lossless transmission line
(a) $Zo = \sqrt{(LC)}$ (b) $Zo = LC$
(c) $Zo = \sqrt{(L/C)}$ (d) $Zo = L/C$

(vi) In good conductors, which condition will be true?
(a) $\sigma/\omega\varepsilon = 1$ (b) $\sigma/\omega\varepsilon >> 1$
(c) $\sigma/\omega\varepsilon << 1$ (d) $\sigma\omega\varepsilon < 1$

(vii) A 50Ω transmission line is terminated at a load $Z_L = 30 + 20j$. The value of standing wave will be
(a) 2.82 (b) 2.04
(c) 1.30 (d) 8.01

(viii) A loss-less 50 Ω line terminates at $Z_L = 78j\ \Omega$. The input impedance at $\lambda/4$
(a) $\propto 78\ j\Omega$ (b) $\propto 39\ j\Omega$
(c) $\propto -0.026\ j\Omega$ (d) $\propto -0.013\ j\Omega$

(ix) The directivity of an antenna is the ratio of
(a) maximum radiation intensity to the average radiation intensity
(b) average radiation intensity to the maximum radiation intensity
(c) maximum radiation pattern to the average radiation pattern
(d) average radiation pattern to the maximum radiation pattern.

(x) Angular width between the first nulls or first side lobes is called
(a) HPBW (b) FNBW
(c) beam area (d) directivity.

Group – B

2. (a) State Maxwell's equations for time varying electromagnetic field wave. *[(CO1) (Remember/LOCQ)]*

(b) Show that the tangential components of electric fields are continuous across the boundary between two dielectric media. *[(CO1) (Understand/LOCQ)]*

(c) Calculate the induced emf due to moving loop in static **B** field. *[(CO1) (Analyze/IOCQ)]*

(d) A circular loop of radius 0.15 m and resistance 10 ohm is immersed in a magnetic field of uniform flux density of magnitude $\mathbf{B}$ = 0.25sin 10^3t $\mathbf{a_z}$ T perpendicular to the plane of the loop. Calculate the induced emf and current through the loop. *[(CO1) (Analyze/IOCQ)]*

2 + 3 + 3 + 4 = 12

3. (a) Define uniform plain wave. *[(CO1) (Remember/LOCQ)]*

(b) In free space $\mathbf{E}$ = 20cos (ωt-50x) $\mathbf{a_y}$V/m. Calculate (a) $\mathbf{J_D}$ (b) $\mathbf{H}$ (c) ω. *[(CO1) (Analyze /LOCQ)]*

(c) Show that for time varying electromagnetic field
$\mathbf{E} = -\nabla V - \frac{\partial \mathbf{A}}{\partial t}$ (Symbols have their usual meanings). *[(CO1) (Analyze/IOCQ)]*

(d) State Lenz's Law. *[(CO1) (Remember/LOCQ)]*

2 + 5 + 3 + 2 = 12

Group - C

4. (a) Show that total power leaving the volume equals to the rate of decrease in energy stored in EM field less the power lost in ohmic dissipation. *[(CO2) (Remember/LOCQ)]*

(b) An EM wave incidents normally at a dielectric-dielectric interface having intrinsic impedances η_1 and η_2, respectively. Show that the reflection and transmission coefficients can be expressed as $\Gamma = \frac{n_1 - n_2}{n_2 + n_1}$ and $\tau = \frac{2n_2}{n_1 + n_2}$, where

n_1 and n_2 are the refractive indices of the respective mediums. Assume both the dielectrics are non-magnetic. *[(CO2, CO3) (Analyze/LOCQ)]*

6 + 6 = 12

5. (a) Electric field corresponding to an EM wave is given as $\vec{E} = 0.5e^{-z/3}\cos(2\pi 10^6 t - 0.021\,z)\ \hat{\boldsymbol{a}}_x + 0.8e^{-z/3}\sin(2\pi 10^6 t - 0.021\,z)\ \hat{\boldsymbol{a}}_y$. Identify the type of polarisation. What is the phase difference between two components of the electric field? *[(CO2) (Understand/LOCQ)]*

(b) Using suitable diagrams explain the differences between p-polarized and s-polarized wave. What is Brewster's angle and which polarization exhibits Brewster's phenomena? *[(CO2) (Understand/LOCQ)]*

4 + (3 + 5) = 12

Group - D

6. (a) The current and voltage equation of transmission line are given as $-\frac{\partial I(z,t)}{\partial z} = GV(z,t) + C\frac{\partial V(z,t)}{\partial t}$ and $-\frac{\partial V(z,t)}{\partial z} = RI(z,t) + L\frac{\partial I(z,t)}{\partial t}$, respectively. Show that the propagation constant $= \sqrt{(R + j\omega L)(G + j\omega C)}$. *[(CO3) (Remember/LOCQ)]*

(b) A transmission line operating at 500 MHz has $Z_0 = 80\,\Omega$, $\alpha = 0.04$ Np/m, $\beta = 1.5$ rad/m. Find the parameters R, L, G, C. *[(CO3) (Remember/LOCQ)]*

(c) A distortion-less line has $Z_0 = 60$, $\alpha = 20$ mNp/m. $0.6c$, where c is the speed of light in vacuum. Find R, L, G, C and λ at 100 MHz. *[(CO3) (Analyze/IOCQ)]*

3 + 5 + 4 = 12

7. (a) Describe the working function of quarter wave transformer and mention the drawbacks. *[(CO4) (Remember/LOCQ)]*

(b) A 60 Ω lossless line is connected to a source with $V_g = 10\angle 0^0 V_{rms}$, Z_g = 50-j40 Ω and terminated with a load j40 Ω. If the line is 100 m long and β = 0.25 rad/m. Calculate Z_{in} and V at the sending end. *[(CO3) (Analyze/IOCQ)]*

(c) A 75 Ω transmission line is terminated by a load 120+j80 Ω. Find Γ and s. Determine how far from the load is the input impedance purely resistive. *[(CO4) (Analyze/IOCQ)]*

4 + 4 + 4 = 12

Group - E

8. (a) Calculate the amount of power radiation for Hertzian dipole antenna. *[(CO5) (Remember/LOCQ)]*

(b) Calculate the effective area of a Hertzian dipole operating at 100 MHz. *[(CO5) (Analyze/IOCQ)]*

(c) Derive the expression for resultant radiation pattern of two-element array. *[(CO5) (Analyze/IOCQ)]*

6 + 2 + 4 = 12

9. (a) Derive expressions for electric and magnetic fields for Hertzian dipole antenna. *[(CO5,CO6) (Remember/LOCQ)]*

(b) A Hertzian dipole of length $\frac{\lambda}{100}$ is located at the origin and fed with a current of $0.25 \sin 10^8 t$ A. Determine the magnetic field at

i. $r = \frac{\lambda}{5}, \theta = 30°$

ii. $r = 200\lambda, \theta = 60°$. *[(CO5,CO6) (Understand/LOCQ)]*

(c) Show that the directive gain of the Hertzian dipole is $G_d(\theta, \phi) = 1.5 \sin^2 \theta$. *[(CO4) (Analyse/IOCQ)]*

4 + 4 + 4 = 12

Cognition Level	*LOCQ*	*IOCQ*	*HOCQ*
Percentage distribution	*63.55*	*34.42*	*0*

Course Outcome (CO):

After the completion of the course students will be able to

1. Apply their pre-requisite knowledge of Electrostatics and Magneto statics.
2. Comprehend Electromagnetic wave propagation in different mediums.
3. Understand different electromagnetic phenomena associated with Transmission Lines.
4. Design of Impedance Matching Networks for two wire Transmission Lines.
5. Develop the ability to analyze the radiation characteristics of antenna configurations and identify respective areas of application.
6. Understand pattern synthesis and analysis in linear antenna array.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*