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) In a certain medium E=10 e^{-3y} cos(10^8t-3y)a_x V/m what type of medium is it?
(a) Free space (b) Lossless dielectric
(c) Lossy dielectric (d) Both (a) and (b).

(ii) The intrinsic impedance of free space is in ohm is
(a) 489 (b) 265 (c) 192 (d) 377.

(iii) If an electromagnetic wave is incident obliquely at the surface of a dielectric medium 2 (μ_2, ϵ_2) from dielectric medium 1 (μ_1, ϵ_1), the average angle of incidence and the critical angle are θ_i and θ_c respectively. The total internal reflection occurs for
(a) $\epsilon_1 > \epsilon_2, \theta_i < \theta_c$ (b) $\epsilon_1 < \epsilon_2, \theta_i < \theta_c$
(c) $\epsilon_1 < \epsilon_2, \theta_i > \theta_c$ (d) $\epsilon_1 > \epsilon_2, \theta_i > \theta_c$

(iv) Which one of the following conditions will not guarantee a distortionless transmission line?
(a) $R = 0, G = 0$ (b) $LG = RC$
(c) $R \gg \omega L, G \gg \omega C$ (d) $R \ll \omega L, G \ll \omega C$.

(v) Which condition satisfies for good conductor?
(a) $\sigma/\omega\varepsilon >> 1$ (b) $\sigma\omega\varepsilon > 1$
(c) $\sigma/\omega\varepsilon << 1$ (d) $\sigma\omega\varepsilon < 1$.

(vi) If a line is terminated in an open circuit, then VSWR (Voltage Standing Wave Ratio) is
(a) 0 (b) 1 (c) ∞ (d) -1

(vii) The skin effect is a phenomenon observed in
(a) Insulators (b) Dielectrics
(c) Conductors (d) Semiconductors.

(viii) The leakage current in the transmission lines is referred to as the
(a) Resistance (b) Radiation
(c) Conductance (d) Polarisation

(ix) A lossy, isotropic and charge free medium means
(a) $\sigma = 0, \epsilon$ is not constant and $\rho = 0$ (b) $\sigma = 0, \epsilon$ is constant and $\rho = 0$
(c) $\sigma \neq 0, \epsilon$ is not constant and $\rho = 0$ (d) $\sigma \neq 0, \epsilon$ is constant and $\rho = 0$

(x) In a dielectric medium, electromagnetic wave with different wavelength experiences different velocity due to
(a) diffraction (b) refraction (c) dispersion (d) all of the above.

Group - B

2. (a) Find the expression for motional emf for moving loop in static B field. [(CO1)(Remember/LOCQ)]

(b) A 30-cm by 40-cm rectangular loop rotates at 130 rad/s in a magnetic field 0.06 Wb/m^2 normal to the axis of rotation. If the loop has 50 turns, determine the induced voltage in the loop. [(CO1)(Analyze/IOCQ)]

(c) Express Maxwell's time varying equations in integral form. [(CO1)(Remember/LOCQ)]

5 + 4 + 3 = 12

3. (a) Derive expression for the continuity equation. Derive the modified Ampere's circuit law. What is the origin of the 'displacement current'? [(CO2)(Remember/LOCQ)]

(b) A parallel-plate capacitor with plate area of 5 cm^2 and plate separation of 3 mm has a voltage $50 \sin 10^3 t$ V applied to its plates. Calculate the displacement current assuming $\epsilon = 2\epsilon_0$. [(CO2)(Analyze/IOCQ)]

(2 + 3 + 1) + 6 = 12

Group - C

4. (a) Derive the Maxwell's wave equation and find the expression of propagation constant γ. [(CO2)(Remember/LOCQ)]

(b) A wave, within a nonmagnetic medium with $\epsilon = 3\epsilon_0$, is represented as
$\mathrm{E} = 200e^{-0.05z} \cos(160 \times 10^6 \pi t - \beta z)\ \hat{a}_x$. Determine
(i) refractive index of the medium,
(ii) intrinsic impedance of the medium,
(iii) phase constant β, and the corresponding magnetic field.
[(CO2)(Evaluate/HOCQ)]

6 + 6 = 12

5. (a) Determine the transmission and reflection coefficients for light incidents normally at an Interface of two dielectrics. [(CO3)(Understand/LOCQ)]

(b) In free space ($z \leq 0$), a plane wave with $H_i = 10\cos(10^8 t - \beta z)\hat{\boldsymbol{a}}_x$ mA/m incidents normally on a lossless medium ($\epsilon = 2\epsilon_0, \mu = 8\mu_0$) in region $z \geq 0$. Determine E_r, for the reflected wave. [(CO3)(Evaluate/HOCQ)]

6 + 6 = 12

Group - D

6. (a) A telephone line has the following parameters: R = 40 Ω/m, G = 400 μS/m, L = 0.2 μH/m, C = 0.5 nF/m
   (i) If the line operates at 10 MHz, calculate the characteristic impedance Z_o and velocity u.
   (ii) After how many meters will the voltage drop by 30 dB in the line?
   [(CO3)(Analyze/IOCQ)]

   (b) Explain the statement-'A lossless line is a distortionless line but it is not viceversa'. [(CO3)(Understand/LOCQ)]

   (c) If a short circuit load is connected at the end of a transmission lines then explain how input impedance vary with length of transmission line.
   [(CO3)(Understand/LOCQ)]

5 + 3 + 4 = 12

7. (a) Explain requirements of stub matching. [(CO4)(Remember/LOCQ)]

   (b) Define standing wave ratio and find relation between SWR and reflection coefficient. [(CO4)(Remember/LOCQ)]

   (c) A lossless transmission line with $Z_0 = 50\Omega$ is 30m long and operates at 2MHz. The line is terminated with a load $Z_L = 60 + j40\Omega$. If u = 0.6c on the line, Find
   (i) Reflection coefficient
   (ii) Standing wave ratio
   (iii) Input impedance. [(CO4)(Analyze/IOCQ)]

3 + 4 + 5 = 12

Group - E

8. (a) The magnetic field of certain antenna at very large distance r is given as

$$\mathrm{H} = j\frac{I_0 dl\beta}{4\pi r}\sin\theta\, e^{j\beta r}\,\hat{a}_\phi.$$

   Find the corresponding electric field. Also find the time-averaged radiated power in free space. [(CO5)(Remember/LOCQ)]

   (b) Define radiation intensity $U(\theta, \phi)$ and establish a relation between average radiation intensity U_{ave} and total time averaged radiated power P_{rad}. Define directive gain $G_d(\theta, \phi)$, hence show that the time averaged power for an isotropic antenna is $P_t = \frac{P_{\text{rad}}}{4\pi r^2}$. [(CO5)(Analyse/IOCQ)]

(3 + 3) + (2 + 1 + 3) = 12

9. (a) Prove that the directive gain of the Hertzian dipole is $G_d(\theta,\phi) = 1.5\sin^2\theta$. [(CO5)(Analyze/IOCQ)]

   (b) Explain how antenna array affects radiation pattern. [(CO5)(Understand/LOCQ]

(c) State Frii's transmission equation for antenna propagation.

[(CO5)(Understand/LOCQ)]

5 + 4 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	55.21	32.29	12.50

Course Outcome (CO):

After going through this course, the 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