EM THEORY & TRANSMISSION LANES
(ECE2203)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) Which equation will hold good for a magnetic material?
(a) Line integral of B is zero (b) Surface integral of H is zero
(c) Line integral of H is zero (d) Surface integral of B is zero

(ii) For a time-harmonic electric field $\mathbf{E}= E_0 e^{(\omega t - kz)}\ \mathbf{a_y}$ in free space, which of the following expressions represents the wave number k?
(a) $k = \omega/c$ (b) $k = c/\omega$ (c) $k= \omega/\epsilon_0\mu_0$ (d) $k= 1/\sqrt{\epsilon_0\mu_0}$

(iii) The flux through each turn of a 100-turn coil is $(t^3 - 2t)$ mWb, where t is in seconds. The induced emf at $t = 2$ s is
(a) 1V (b) -1V (c) 4Mv (d) 0.4V

(iv) Which of the following equations is not Maxwell's equation
(a) $\nabla \cdot \boldsymbol{J} + \frac{\partial \rho_v}{\partial t} = 0$ (b) $\nabla \cdot \boldsymbol{D} = \rho_v$
(c) $\nabla \times \boldsymbol{E} = -\frac{\partial \boldsymbol{B}}{\partial t}$ (d) $\oint \boldsymbol{H} \cdot d\boldsymbol{l} = \int \left(\sigma \boldsymbol{E} + \epsilon \frac{\partial \boldsymbol{E}}{\partial t}\right) \cdot d\boldsymbol{S}$

(v) If $\boldsymbol{E}_s = 10\ e^{j4x}\ \boldsymbol{a}_y$, which of the following is incorrect representation of $\boldsymbol{E}$?
(a) $\mathrm{Re}\left(\boldsymbol{E}_s e^{j\omega t}\right)$ (b) $\mathrm{Im}\left(\boldsymbol{E}_s e^{j\omega t}\right)$
(c) $10\cos(\omega t + j4x)$ (d) $10\sin(\omega t + 4x)$

(vi) Given that the reflection coefficient is 0.6. Find the SWR.
(a) 2 (b) 4 (c) 6 (d) 8

(vii) Find the characteristic impedance expression for lossless transmission
(a) Zo = L/C (b) Zo = √(L/C)
(c) Zo = √(LC) (d) Zo = LC

(viii) The radiation resistance of a Hertzian dipole is typically very small because
(a) The dipole is electrically large (b) The dipole is a short current element
(c) It operates at high frequencies (d) It has a high input impedance

(ix) The radiation pattern of a Yagi-Uda antenna is
(a) Omnidirectional
(b) Bidirectional
(c) Highly directional with a main lobe in the direction of the director
(d) Isotropic

(x) A linear array of 6 elements is designed to operate at 2.5 GHz with an inter-element spacing of 0.2λ. What is the physical distance between the elements in meters?
(a) 0.012 m (b) 0.024 m (c) 0.036 m (d) 0.048 m

Fill in the blanks with the correct word

(xi) $\frac{\partial \boldsymbol{D}}{\partial t}$ is called as _____ current.

(xii) Two dielectric mediums are characterized by $\eta_1 = 5$ and $\eta_2 = 3$. The reflection coefficient from medium 2 to medium 1 is _____.

(xiii) The condition for a distortionless line is _____.

(xiv) A load impedance of 250 ohm is connected to a 75 ohm line. Reflection coefficient is_____.

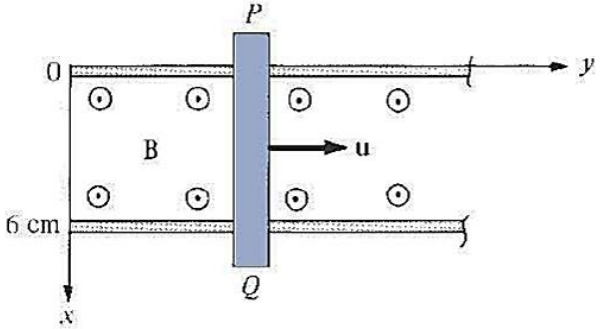
(xv) If an antenna array has elements spaced by λ/2, the phase difference required for broadside radiation is _____ degrees.

Group - B

2. (a) Write Maxwell's equations in point form. *[(CO1)(Remember/LOCQ)]*
(b) In a charge-free region for which σ = 0, μ = μ_o, and ε=$\varepsilon_0\varepsilon_r$
$\boldsymbol{H} = 5\cos(10^{11}\, t - 4y)\, \mathbf{a_z}$ A/m
Find: (a) $\mathbf{J_d}$ and **D**, (b)ε_r *[(CO1)(Analyse/IOCQ)]*
(c) Differentiate between induced EMF and electrostatic potential. *[(CO1)(Remember/LOCQ)]*

3 + 7 + 2 = 12

3. (a) A conducting loop is moving with a velocity $\boldsymbol{u}$ in a time varying magnetic field $\boldsymbol{B}$. With proper explanation, derive expression of induced emf and corresponding electric field. *[(CO1)(Remember/LOCQ)]*
(b) A conducting bar can slide freely over two conducting rails. Evaluate the induced voltage in the bar if the bar slides at a velocity $\boldsymbol{u} = 20\,\hat{\boldsymbol{a}}_y$ m/s and $\boldsymbol{B} = 4\cos(10^6 t - y)\ \hat{\boldsymbol{a}}_z$ mWb/m^2. *[(CO1)(Evaluate/HOCQ)]*



6 + 6 = 12

Group - C

4. (a) In terms of η, β, α and $\boldsymbol{u}$ of plane wave, compare the propagation in free space and in lossless dielectric medium *[(CO3)(Remember/LOCQ)]*

   (b) A lossless dielectric has an intrinsic impedance of $200\angle 30^o\ \Omega$ at a particular frequency ω, If, at that frequency, the plane wave propagating through the dielectric has the magnetic field component

$$\boldsymbol{H} = 10e^{-\alpha x}\cos\left(\omega t - \frac{1}{2}x\right)\hat{\boldsymbol{a}}_y\ A/m$$

   Find $\boldsymbol{E}$ and α. Determine the skin depth and wave polarization. *[(CO3)(Apply/HOCQ)]*

6 + 6 = 12

5. (a) Derive Poynting's theorem. *[(CO3)(Remember/LOCQ)]*

   (b) In a nonmagnetic medium $\boldsymbol{E} = 4\sin(2\pi \times 10^7 t - 0.8x)\hat{\boldsymbol{a}}_z$ V/m. Find the time-averaged power carried by the wave. *[(CO3)(Analyze/IOCQ)]*

6 + 6 = 12

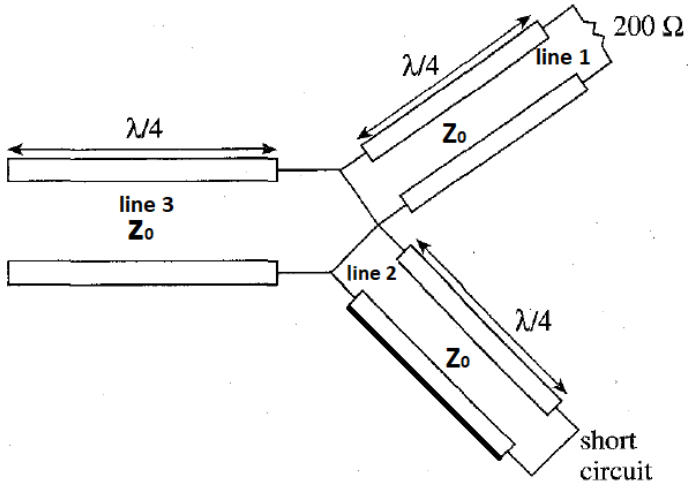
Group - D

6. (a) Derive the characteristic impedance of a transmission line having length L. *[(CO3)(Analyse/IOCQ)]*

   (b) A distortionless line operating at 120 MHz has R = 20 Ω/m, L = 0.3 μH/m, and C = 63 pF/m. (a) Determine γ, u, and Z_o. (b) How far will a voltage wave travel before it is reduced to 20% of its initial magnitude? *[(CO3)(Analyse/IOCQ)]*

6 + 6 = 12

7. (a) Consider the three lossless lines in Figure.



   If $Z_o = 50\Omega$, Evaluate
   (i) Z_{in} looking into line 1
   (ii) Z_{in} looking into line 2
   (iii) Z_{in} looking into line 3 *[(CO4)(Evaluate/HOCQ)]*

   (b) Find the voltage reflection coefficient at the load end for a transmission line circuit connect to a load Z_L. Assume characteristic impedance of transmission line is Z_0 *[(CO3)(Remember/LOCQ)]*

6 + 6 = 12

Group - E

8. (a) A transmitting antenna has an effective aperture of 0.5 m^2 and operates at 3 GHz. Calculate its directivity. *[(CO5)(Analyse/HOCQ)]*

   (b) Define a half-wave dipole antenna and describe its radiation pattern. *[(CO5)(Remember/LOCQ)]*

   (c) What is the difference between beamwidth and directivity? How does beamwidth affect antenna performance? *[(CO5)(Apply/IOCQ)]*

3 + 4 + 5 = 12

9. (a) Compare and contrast a uniform and a non-uniform linear antenna array in terms of excitation, directivity, and sidelobe control. *[(CO6)(Analyse/HOCQ)]*

   (b) Explain the role of the array factor in determining the radiation pattern of a linear antenna array. *[(CO6)(Remember/LOCQ)]*

   (c) A uniform linear array consists of 5 isotropic elements spaced $\lambda/2$ apart. Determine the array length if the operating frequency is 3 GHz. *[(CO6)(Apply/IOCQ)]*

4 + 4 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	38.54	35.42	26.04