(vi) Which one of the following general boundary conditions at the interface between two media is incorrect?

(a) $(\overrightarrow{D_1} - \overrightarrow{D_2}).\overrightarrow{a_n} = \rho_s$ (b) $(\overrightarrow{B_1} - \overrightarrow{B_2}).\overrightarrow{a_n} = 0$

(c) $\overrightarrow{a_n} \times (\overrightarrow{H_1} - \overrightarrow{H_2}) = -\overrightarrow{J_s}$ (d) $\overrightarrow{a_n} \times (\overrightarrow{E_1} - \overrightarrow{E_2}) = 0$

(vii) While using mobile phone within elevators, call drop may occur due to

(a) $\alpha = \sqrt{\pi f \mu \sigma}$ (b) $\beta = \sqrt{\pi f \mu \sigma}$

(c) $\delta = \dfrac{1}{\sqrt{\pi f \mu \sigma}}$ (d) both (a) and (c).

(viii) The input impedance of a half wave lossless transmission line of characteristic resistance of 50 Ω is terminated in a load resistance of 75 Ω is

(a) 75 Ω (b) 50 Ω

(c) 33.33 Ω (d) 11.25 Ω.

(ix) An open circuited load of a lossless transmission line is located on the Smith chart at

(a) extreme left point on the real u axis of the constant r = ∞ circle.
(b) extreme right point on the real u axis of the constant r = ∞ circle.
(c) extreme left point on the real u axis of the constant r = 0 circle.
(d) extreme right point on the real u axis of the constant r = 0 circle.

(x) The power flow through a straight wire of circular cross section aligned along z axis through which a direct current flows in the negative z direction is

(a) along the positive z direction
(b) along the negative z direction
(c) in the radially inward direction
(d) radially outward in the conductor.

Group – B

2. (a) Let $\mathbf{A} = \rho \cos\phi \mathbf{a}_\rho + \rho z^2 \sin\phi \mathbf{a}_z$. Transform into rectangular coordinates and calculate its magnitude at point $(3, -4, 0)$.

(b) Given a vector field $\mathbf{D} = r\sin\phi \mathbf{a}_r - \dfrac{1}{r}\sin\theta\cos\phi \mathbf{a}_\theta + r^2 \mathbf{a}_\phi$. Determine $\mathbf{D}$

(i) at $P(10, 150^\circ, 330^\circ)$

(ii) the component of $\mathbf{D}$ tangential to the spherical surface $r = 10$ at P.

(iii) the vector at P perpendicular to $\mathbf{D}$ and $\mathbf{a}_\theta$.

6 + (1 + 2 + 3) = 12

3. (a) Establish relation between Electric field and potential.

(b) Show that the static electric field $\vec{E}$ due to a point charge is irrotational.

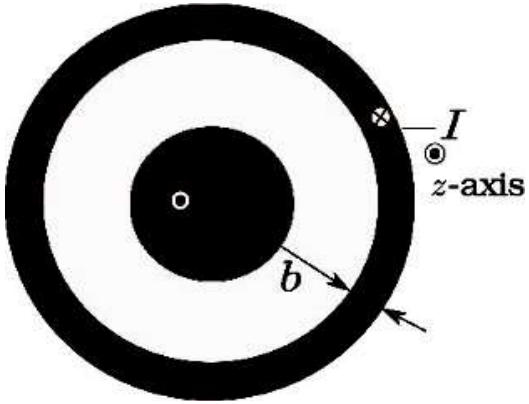
(c) A parallel plate capacitor is filled with a dielectric medium, the relative permittivity of which varies linearly from one plate of the capacitor to the other, separated by a distance d from ε_{r1} to ε_{r2}. Obtain an expression for the capacitance of the capacitor C in terms of ε_{r1}, ε_{r2}, d and A the plate area, the dimensions of the plate considered large compared to d.

3 + 3 + 6 = 12

Group – C

4. (a) State Biot-Savart law. Using such a law, find the magnetic field around a line placed on the z axis while, carrying a steady current I.

(b) Suppose a coaxial transmission line is placed on the z axis, as shown in the figure below. The inner core of radius a is carrying a current I towards you while the outer core having radius b and thickness t is carrying $-I$ into the page. Using Ampere's law, find the magnetic fields everywhere around the transmission line. Prepare a plot illustrating the variations of the field strength with respect to the radial vector ρ.



(1 + 5) + (5 + 1) = 12

5. (a) Starting from Maxwell's equation establish the wave equation in electric field in a source present (volume charge density ρ ≠ 0 and current density J ≠ 0) medium in terms of the volume charge density and current density.

(b) A region is divided in to two parts: region 1 [$z \le 0$; $\mu_1 = 60\ \mu_0$ (iron)] and region 2 [$z \ge 0$; $\mu_2 = \mu_0$ (free space)], across the interface z = 0. Hence determine $\overrightarrow{B_2}$ if $\overrightarrow{B_1} = 6\overrightarrow{a_x} + 12\overrightarrow{a_y}$ T.

6 + 6 = 12

Group – D

6. (a) If a transmission line of characteristic resistance 50 Ω is terminated in complex impedance 25 + j100 Ω, what will be the reflection coefficient and the VSWR of the line?

(b) What do you understand by the reflection coefficient and the voltage standing wave ratio VSWR of a transmission line? Deduce the relation between them.

6 + (3 + 3) = 12

7. (a) Using suitable diagram show that the voltage at any point in a transmission line can be expressed as $V(z) = V_0^+ e^{-\gamma z} + V_0^- e^{\gamma z}$, where V_0^+ and V_0^- represent initial values at the source and load point. Also find the expression of γ in terms of the line parameters.

(b) A distortion-less line has $Z_0 = 60\Omega$, $\alpha = 20$ mNp/m, u = 0.6c and $\beta = 1.5$ rad/m. Find the line parameters R, L, G, C and λ at 100 Mhz.

6 + 6 = 12

Group – E

8. (a) Derive Friis Transmission formula for two antenna system.

(b) Radiated power density is given as $W = \frac{A_m \sin^2\theta}{r^2}$. What will be the value of directivity?

(c) Express E and H fields of an Hertzian dipole for (i) near field (ii) intermediate field (iii) far field regions.

4 + 3 + (2 + 2 + 2) = 12

9. (a) Discuss the advantages of using an array of antenna elements over a single antenna element.

(b) Explain the following antenna parameters:
(i) Directivity (ii) Gain (iii) Aperture Efficiency (iv) Radiation Resistance.

(c) Deduce the expression for FNBW and HPBW of a uniform broadside array in terms of number of elements, the separation between the elements and the wavelength.

3 + (1 + 1 + 1 + 1) + 5 = 12

EM THEORY & TRANSMISSION LINE
(ECEN 2201)

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) Which of the following expression is incorrect
(a) $\nabla . \vec{E} = \rho$
(b) $\nabla . \vec{B} = 0$
(c) $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$
(d) $\oint \vec{H} . \overrightarrow{dl} = \int_s \left(\vec{J} + \frac{\partial \vec{D}}{\partial t}\right) . \overrightarrow{a_n} dS$

(ii) The unit of magnetic vector potential is
(a) Wb/m (b) Wb/m^2
(c) T/m (d) T/m^2.

(iii) Due to a net negative charge $\rho(t)\,(C/m^3)$ stored within a volume v enclosed by a surface **s**, the equation $I = \oint J . ds$ can equally be written as
(a) $\nabla \cdot \mathbf{J} = -\frac{d\rho}{dt}$ (b) $\oint J . d\boldsymbol{s} = -\frac{d}{dt}\int \rho\, dv$
(c) both (a) and (b) (d) none of the above.

(iv) The point charge q' at the centre of a system of point charges, each q, situated at the corners of a square will keep the system in equilibrium if
(a) q' = -4q (b) q' = 0
(c) q' = -[(1+2√2)/4] q (d) q' = -[(1+4√2)/4] q.

(v) The line parameters used for a transmission line are assumed as
(a) lumped (b) distributed
(c) discrete (d) all of the above.