Code: A-14 **Subject: ELECTROMAGNETICS AND RADIATION**
Time: 3 Hours **Max. Marks: 100**

NOTE: There are 11 Questions in all.

- **Question 1 is compulsory and carries 16 marks. Answer to Q. 1. must be written in the space provided for it in the answer book supplied and nowhere else.**
- **Answer any THREE Questions each from Part I and Part II. Each of these questions carries 14 marks.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 Choose the correct or best alternative in the following: (2x8)

a. The boundary condition valid at the boundary between two dielectrics 1 and 2 is

(A) $E_{t_1} = E_{t_2}$. **(B)** $E_1 = E_2$.

(C) $D_{n_1} = D_{n_2}$. **(D)** both **(A)** and **(C)**.

b. The magnetic field at any point on the axis of a current carrying circular coil will be

(A) perpendicular to the axis.
(B) parallel to the axis.
(C) at an angle of 45^0 with the axis.
(D) zero.

c. Which of the following matching is incorrect:

(A) Continuity equation : $\nabla \cdot \vec{J} = -\frac{d\rho}{dt}$.

(B) Faraday's Law : $\nabla \times \vec{E} = -\frac{d\vec{B}}{dt}$.

(C) Ampere's circuital law : $\nabla \times \vec{H} = \vec{J} + \frac{d\vec{D}}{dt}$.

(D) Poisson's equation : $\nabla^2 V = 0$.

d. Skin depth is proportional to

(A) frequency. **(B)** permeability.

(C) $1/\sqrt{\sigma}$. **(D)** $\sqrt{\sigma}$.

e. For a line of characteristic impedance, Z_0 terminated in a load Z_R such that $Z_R = Z_0/3$, the reflection coefficient is

(A) $\frac{1}{3}$. **(B)** $\frac{2}{3}$.
(C) $-\frac{1}{3}$. **(D)** $-\frac{1}{2}$.

f. For a Z_0-terminated line, which one of the following is incorrect

(A) it is a smooth line.
(B) the energy distribution between magnetic and electric field is not equal.
(C) standing wave does not exist.
(D) efficiency of transmission of power is maximum.

g. For a rectangular wave guide, $2.5\text{cm} \times 1.2\text{cm}$, dominant cut off wavelength is

(A) 5 cm. **(B)** 2.5 cm.
(C) 2.4 cm. **(D)** 3.7 cm.

h. The directive gain cannot be stated as
(A) the ratio of the radiation intensity in that direction to the average radiated power.
(B) the function of angles.
(C) the directivity of an antenna when directive gain is maximum.
(D) independent of angles.

PART I

Answer any THREE Questions. Each question carries 14 marks.

Q.2 a. State and explain Gauss's law for the electric field in differential form. How is it derived from its integral form? **(3 + 4)**

b. A spherical volume charge density distribution is given by $\rho = \rho_0\left(1 - \frac{r^2}{a^2}\right)$; for $(r \le a)$
$= 0$; for $r > a$

(i) Calculate the total charge Q.

(ii) Find the electric field intensity $\vec{E}$ outside the charge distribution.

(iii) Find the electric field intensity $\vec{E}$ inside. **(7)**

Q.3 a. What is displacement current? Compare and contrast displacement current with current due to flow of charges. **(2 + 6)**

b. Given the conduction current density in a lossy dielectric as $J_c = 0.02 \sin 10^9 t \left(\frac{A}{m^2}\right)$, find the displacement current density if $\sigma = 10^3$ mho / m and $\epsilon_r = 6.5$. **(6)**

Q.4 a. State the continuity equation and discuss its physical interpretation. Summarize Maxwell's equations in differential form. **(4 + 4)**

b. In free space,

$\vec{D} = D_m \sin(\omega t + \beta z)\hat{i}_x$

using Maxwell's equations, show that

$\vec{B} = \frac{\omega \mu_o D_m}{\beta} \sin(\omega t + \beta z)\hat{i}_y$ **(6)**

Q.5 a. Discuss the boundary conditions at the interface between two perfect dielectric media. **(8)**

b. A medium has the following parameters:

$\mu_r = 10; \epsilon_r = 2.5; \sigma = 10^{-4}$ mho/metre . Determine $\alpha, \beta, \lambda, v, \eta$ for 1GHz. **(6)**

Q.6 a. What is Poynting vector? What is the physical interpretation of the Poynting vector over a closed surface? **(3 + 4)**

b. Using Laplace's equation, for a parallel plate capacitor with the plate surfaces normal to x-axis, find the potential at any point between the plates. Given $V = V_1$ at $x = x_1$ and $V = V_2$ at $x = x_2$. **(7)**

PART II

Answer any THREE Questions. Each question carries 14 marks.

Q.7 a. Discuss in brief the concept of the distributed circuit as compared to a lumped circuit. Derive an expression for the characteristic impedance (Z_o), attenuation constant (α) and phase velocity (v_p) in terms of primary constants. **(2 + 6)**

b. How do frequency distortion and delay distortion arise in a telephone line? Derive a condition for a distortionless line and explain how this can be approximated in practice. **(6)**

Q.8 a. Explain how matching stub can be used to match a high frequency line supplying power to a load impedance. Why is the matching necessary? **(6 + 2)**

b. Explain how transmission lines can be used as resonant circuit elements. **(6)**

Q.9 a. Show that TM_{01} and TM_{10} modes cannot propagate in a rectangular waveguide. **(7)**

b. What are the dimensions of a rectangular waveguide with the following specifications?

(i) At a frequency of 9959.5 MHz, the guide wavelength for TE_{10} mode is 87.57% of cutoff wavelength.

(ii) TE_{30} and TE_{12} modes have the same cutoff frequency. **(7)**

Q.10 a. Define directivity of an antenna. What is the difference between gain and directivity? **(2 + 4)**

b. Explain the following :

(i) Radiation resistance.

(ii) Beam width of an antenna.

(iii) Effective height (effective length)

(iv) Array factor. **(8)**

Q.11 a. Show that the width of the principal lobe of a uniform end fire array is greater than that for a uniform broadside array of the same length. What is the effect of the number of elements present in the array on the radiation pattern? **(5 + 3)**

b. State the different layers of ionosphere. Which layers disappear at night? Why is ground wave propagation called medium wave propagation? **(4 + 2)**