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. Two concentric spherical shells carry equal and opposite uniformly distributed charges over their surfaces as shown in Fig.1.
Electric field on the surface of inner shell will be

(A) zero.

(B) $\frac{Q}{4\Pi\epsilon_0 R^2}$.

(C) $\frac{Q}{8\Pi\epsilon_0 R^2}$.

(D) $\frac{Q}{16\Pi\epsilon_0 R^2}$.

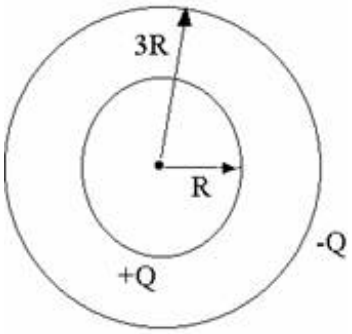

Fig.1

b. The magnetic field intensity (in $^{A}/_{m}$) at the centre of a circular coil of diameter 1 metre and carrying current of 2 A is

(A) 8. **(B)** 4.
(C) 3. **(D)** 2.

c. The polarization of a dielectric material is given by

(A) $\vec{P} = \epsilon_r \vec{E}$. **(B)** $\vec{P} = (\epsilon_r - 1)\vec{E}$.

(C) $\vec{P} = \vec{E}\,\epsilon_0 (\epsilon_r - 1)$. **(D)** $\vec{P} = (\epsilon_r - 1)\epsilon_0$.

d. In a travelling electromagnetic wave, E and H vector fields are

(A) perpendicular in space .
(B) parallel in space.
(C) E is in the direction of wave travel.
(D) H is in the direction of wave travel.

e. For a line of characteristic impedance Z_0, terminated in a load Z_R such that $Z_R = 4Z_0$, the reflection coefficient is

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

(C) $\frac{3}{5}$. **(D)** 1.

f. For a distortionless transmission line which of the following statements is incorrect

(A) LG = CR.
(B) attenuation constant, α should be independent of frequency.
(C) phase constant, β should be independent of frequency.
(D) hypothetical line requires very large value of inductance (L).

g. Which of the following modes does not exist in a rectangular waveguide

(A) TE_{10}. **(B)** TE_{01}.

(C) TM_{01}. **(D)** TM_{11}.

h. For a broad side linear array which of the following is not correct

(A) the maximum radiation occurs perpendicular to the line of the array at $\phi = 90^\circ$.
(B) the progressive phase shift (α) between elements is zero.
(C) width of principal lobe is less than that of an end fire array.
(D) the maximum radiation occurs along the line of array at $\phi = 0^\circ$.

PART I
Answer any THREE Questions. Each question carries 14 marks.

Q.2 a. Using Gauss's theorem, show that a symmetrical spherical charge distribution is equivalent to a concentrated point charge at the centre of the sphere as far as external fields are concerned. **(6)**

b. A spherical volume of radius R has a volume charge density given by $\rho = Kr$, where r is the radial distance and K is a constant. Develop expressions for $\vec{E}$ and V and sketch their variation with respect to $r(0 \le r \le \infty)$. **(8)**

Q.3 a. Give an example in which the current in a wire enclosed by a closed path is not a uniquely defined. Is it correct to apply Ampere's circuital law for the static case in such a situation? Explain. **(6)**

b. The electric field $\vec{E}$ in free space is given as $E = E_m \cos(\omega t - \beta z)\hat{i}_x$.

Determine $\vec{D}, \vec{B}$ and $\vec{H}$. Sketch E and H at t =0. **(8)**

Q.4 a. What is the physical interpretation of Gauss's law for the magnetic field? How gauss' law for the magnetic field in differential form can be derived from it integral form? **(3 + 5)**

b. The one-dimensional Laplace's equation is given as $\frac{d^2V}{dx^2} = 0$. The boundary conditions are V = 9 at x = 1 and V = 0 at x = 10. Find the potential and also show the variation of V with respect to x. **(6)**

Q.5 a. State and explain Biot-Savart's Law relating the magnetic field produced at a point due to current in a small elemental wire. **(6)**

b. Summarize Maxwell's equations in integral form for both static fields and time-varying fields. **(8)**

Q.6 a. What is a uniform plane wave? Why is the study of uniform plane waves important? Discuss the parameters ω, β and v_p associated with sinusoidally time-varying uniform plane waves. **(2 + 2 +4)**

b. Answer in brief:

(i) What is the criterion for a material to be a good conductor?

(ii) What is skin effect?

(iii) Why are low frequency waves more suitable than high frequency waves for communication with under water objects? **(2 + 2 + 2)**

PART II

Answer any THREE Questions. Each question carries 14 marks.

Q.7 a. Distinguish between internal inductance and external inductance. Discuss the concept of flux linkage pertinent to the determination of the internal inductance. **(3 + 3)**

b. Explain the following:

(i) Characteristic impedance.

(ii) Distortionless line.

(iii) Voltage Standing Wave Ratio (VSWR).

(iv) Reflection coefficient. **(8)**

Q.8 a. Explain the impedance transformation property of a quarter wave transmission line. **(7)**

b. Calculate the characteristic impedance Z_0, propagation constant γ and the line constants of an open

wire loss less line of 50 Km long operating at f = 700 Hz if

$$Z_{0C} = 286\angle -40^{\circ}\Omega$$

$$Z_{SC} = 1520\angle 16^{\circ}\Omega$$ **(7)**

Q.9 a. What is dominant mode? Which one of the rectangular waveguide modes is the dominant mode? How do the dimensions of a rectangular cavity resonator determine the frequencies of oscillation of the resonator? **(4+6)**

b. A rectangular waveguide measures $3\times 4.5\text{cm}$ internally and has a 10 GHz signal propagated in it. Calculate the cut off frequency (λ_c) and the guide wavelength (λ_g). **(4)**

Q.10 a. What is a Hertzian dipole? Discuss the time variations of the current and charges associated with the Hertzian dipole. Also discuss the characteristics of the electromagnetic field due to the Hertzian dipole. **(2 + 3 + 3)**

b. Deduce the radiation resistance and the directivity for a half wave dipole? **(6)**

Q.11 a. Distinguish between broadside and end fire radiation patterns with suitable sketches. What is an array factor? Provide a physical explanation for the array factor. **(4 + 4)**

b. Estimate the maximum usable frequency (MUF) for a critical frequency of 10 MHz and an angle of incidence of 45°. **(6)**