Code: A-14 **Subject: ELECTROMAGNETICS AND RADIATION**

December 2005

Time: 3 Hours

Max. Marks: 100

NOTE: There are 9 Questions in all.

- **Question 1 is compulsory and carries 20 marks. Answer to Q. 1. must be written in the space provided for it in the answer book supplied and nowhere else.**
- **Out of the remaining EIGHT Questions answer any FIVE Questions. Each question carries 16 marks.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 Choose the correct or best alternative in the following: (2x10)

a. Two point charges Q_1 and Q_2 are located at A and B on a straight line as shown in the Fig.1. The electric field will be zero at a point

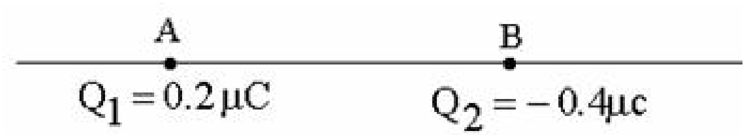

Fig.1

(A) between A and B. **(B)** to the left of A.
(C) to the right of B. **(D)** perpendicular to AB.

b. The ratio of conduction current density to the displacement current density is

(A) $\frac{\sigma}{j\omega\epsilon}$ **(B)** $\frac{j\sigma}{\omega\epsilon}$
(C) $\frac{\sigma\omega}{j\epsilon}$ **(D)** $\frac{\sigma\epsilon}{j\omega}$

Where symbols have their usual meaning.

c. A wave is incident normally on a good conductor. If the frequency of a plane electromagnetic wave increases four times, the skin depth, will

(A) increase by a factor of 2. **(B)** decrease by a factor of 4.
(C) remain the same. **(D)** decrease by a factor of 2.

d. Electric field of a travelling wave is given by $100\cos\left(10^9 t - 4x\right)$. The velocity and the wavelength are

(A) 3×10^8 m/sec and 4 m respectively.

(B) 2.5×10^8 m/sec and $\pi/2$ m respectively.

(C) 4×10^9 m/sec and 8π m respectively.

(D) 10^9 m/sec and $100/4$ m respectively.

e. In a dielectric-conductor boundary (interface), the tangential component of electric field is

(A) E_t **(B)** $2E_t$
(C) zero **(D)** infinity

f. Which of the following matching is incorrect:

(A) Ampere's circuital law $\rightarrow \nabla\times\vec{H} = \vec{J} + \frac{\partial\vec{D}}{\partial t}$.

(B) Displacement current density $\rightarrow \vec{J} = \frac{\partial\vec{D}}{\partial t}$.

(C) Poisson's equation $\rightarrow \nabla^2 V = 0$.

(D) Continuity equation $\rightarrow \nabla\cdot\vec{J} = -\frac{\partial\rho}{\partial t}$.

g. For a transmission line terminated in its characteristic impedance, which of the following statement 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.

h. For a line of characteristic impedance, Z_O terminated in a load, Z_R such that $Z_R > Z_O$, the Voltage Standing Wave Ratio (VSWR) is given by

(A) Z_R/Z_O. **(B)** Z_O.

(C) Z_R. **(D)** Z_O/Z_R.

i. The lower cut-off frequency of a rectangular wave guide with inside dimensions (3×4.5 cm) operating at 10 GHz is

(A) 10 GHz. **(B)** 9 GHz.

(C) $\frac{10}{9}$ GHz. **(D)** $\frac{10}{3}$ GHz.

j. 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.

Answer any FIVE Questions out of EIGHT Questions.
Each question carries 16 marks.

Q.2 a. What are the boundary conditions for static electric fields in the general form at the interface between two different dielectric media? Explain. **(8)**

b. Using Gauss's law in integral form, obtain the electric field due to following charge distribution in spherical coordinates:

Charge density, $$\rho(r,\theta,\varphi) = \begin{cases} K/r^2 & \text{for } 0 < r < R \\ 0 & \text{for } R < r < \infty \end{cases}$$

Where, R is the radius of spherical volume,
K is constant & r is radial distance. **(8)**

Q.3 a. State Poisson's equation. How is it derived? 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 $x = x_2$. **(2+4+4)**

b. State and explain Biot-Savart's law. **(2+4)**

Q.4 a. What is Poynting vector? How is the Poynting theorem derived from Maxwell's curl equations? Explain Poynting theorem. **(2+8)**

b. The conduction current density in a lossy dielectric is given as $J_C = 0.02 \sin 10^9 t \ \ A/m^2$, find the displacement current density if $\sigma = 10^3 \ mho/m$, $\epsilon_r = 6.5$ & $\epsilon_o = 8.854 \times 10^{-12}$. **(6)**

Q.5 a. Derive general expressions for reflection coefficient and transmission coefficient for $\vec{E}$ and $\vec{H}$ fields when an electromagnetic wave is incident normally on the boundary separating two different perfectly dielectric media. **(8)**

b. Consider the volume current density distribution in cylindrical coordinates as

$$J(r, \phi, z) = 0, \quad 0 < r < a$$

$$= J_0 \left(\frac{r}{a}\right)\hat{i}_z, \quad a < r < b$$

$$= 0, \quad b < r < \infty$$

Where a and b are inner and outer radii of the cylinder. Find the magnetic field intensity in various regions. **(8)**

Q.6 a. Calculate the electric field due to a line charge considering it a special Gaussian surface. **(5)**

b. Find out the magnetic field intensity at any point due to a current carrying conductor of finite length using the Biot-Savart law. **(5)**

c. Find the characteristic impedance, propagation constant and velocity of propagation for a transmission line having the following parameters:

R = 84 ohm/Km, $G = 10^{-6}$ mho/Km, L=0.01 Henry / Km,
C=0.061 μF /Km and frequency = 1000 Hz. **(6)**

Q.7 a. How does dissipation-less transmission lines act as tuned circuit elements? Explain. **(9)**

b. What do you mean by matched transmission line? What are the advantages of impedance matching on high frequency lines? **(7)**

Q.8 a. What is a linear array? Define a uniform array? Show that the width of the principal lobe of a uniform end fire array is greater than that for a uniform broad side array of the same length. **(2+3+5)**

b. Find the radiation resistance of a dipole antenna $\lambda/10$ long. Also, find the antenna efficiency if the loss resistance is 1 ohm. **(6)**

Q.9 a. State and explain the different types of propagations possible between a transmitter and receiver. Name the various layers of ionosphere and indicate their approximate height. Which ionospheric layers disappear at night? **(9)**

b. Find the following:

(i) the possible transmission modes in a hollow rectangular waveguide of inner dimension 3.44

$\times$ 7.22 cm at an operating frequency of 3000 MHz.

(ii) the corresponding values of phase velocity, group velocity and phase constant. **(7)**