AMIETE – ET (OLD SCHEME)

Code: AE14   **Subject: ELECTROMAGNETICS AND RADIATION**
Time: 3 Hours   **Max. Marks: 100**

JUNE 2009

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 the best alternative in the following:**   **(2×10)**

a.   The unit of electric field strength $\left|\overline{E}\right|$ is

    (A) Volts/meter.   **(B)** Newton/coulomb.
    (C) Joules/coulomb meter.   **(D)** All.

b.   Which of the following is a ferromagnetic material?

    (A) Copper   **(B)** Palladium
    (C) Silver   **(D)** Cobalt

c.   The magnetic flux emerging from any closed surface is

    (A) Constant.   **(B)** Zero.
    (C) Unity.   **(D)** None.

d.   Maxwell's equation in free space is

    (A) $\nabla.\vec{B} = 0$.   **(B)** $\nabla.\vec{B} = \rho$.
    (C) $\nabla.\vec{B} = J$.   **(D)** $\nabla.\vec{B} = \sigma J$.

e.   Two waves of same frequency have opposite phases, when the phase angle between them is

    (A) 0°.   **(B)** 90°.
    (C) 360°.   **(D)** π radian.

f.   Poynting vector for an electromagnetic wave is equal to

    (A) $\vec{H}.\vec{E}$.   **(B)** $\vec{H}\times\vec{E}$.
    (C) $\vec{E}\times\vec{H}$.   **(D)** $\vec{E}.\vec{H}$.

g.   An electromagnetic wave incident on a perfect dielectric is
    (A) Fully transmitted.
    (B) Fully reflected.
    (C) Partially transmitted and partially reflected.
    (D) None of these.

h.   Polarization of electromagnetic waves is due to

(A) Transverse nature of the waves.
(B) Longitudinal nature of the waves.
(C) Reflection from another medium.
(D) None of the above.

i.   The frequencies in ultra high frequency range are propagated by means of

(A) Ground wave.   (B) Space wave.
(C) Sky wave.   (D) Surface wave.

j.   If length of an antenna is increased, the directive gain

(A) Increases.   (B) Decreases.
(C) Remains the same.   (D) Becomes Infinite.

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

Q.2   a.   State and explain Coulomb's law with relevant diagram.   **(4)**

      b.   A charge of $Q_1 = 3 \times 10^{-4}$ Coulomb at M (1,2,3) and a charge of $Q_2 = 3 \times 10^{-4}$ Coulomb at N (2,0,5) in a vacuum. Calculate the force exerted on Q_2 by Q_1.   **(4)**

      c.   Derive Poisson's equation and Laplace's equation using Maxwell's equation. Also express the Laplace's equation in Rectangular, Cylindrical and Spherical coordinates.   **(8)**

Q.3   a.   Define Biot-Savart law. Also calculate the magnetic field of line current along a thin straight wire of infinite length.   **(8)**

      b.   Explain the detailed boundary conditions of a magnetic field.   **(8)**

Q.4   a.   Write the differential and integral form of Maxwell's equations in conducting medium as well as in free space. Mention clearly the notations used in the equations.   **(8)**

      b.   At the boundary of two perfect dielectric materials having permittivity ε_1 and ε_2, electric flux density D_1 is incident at an angle θ_1 with respect to normal to the boundary surface. Prove that **(8)**
$$D_2 = D_1 \ [\cos^2 \theta_1 + (\varepsilon_2/\varepsilon_1)^2 \sin^2 \theta_1]^{1/2}$$

Q.5   a.   What do you mean by Polarization? Classify different types of Polarizations that occur in wave propagation.   **(8)**

      b.   A 10 GHz plane wave travelling in free space has an amplitude $E_x = 1$ Volt/meter. Find the following:-
        (i) phase velocity, wave length and propagation constant.
        (ii) characteristic impedance of the medium.
        (iii) amplitude and direction of the magnetic field intensity.
        (iv) repeat part (i), if the wave is travelling in a loss less, bounded   medium having permeability the same as free space but   permittivity four times that of free space.   **(8)**

Q.6   a.   Derive the transmission-line equations which characterize the wave propagation along the line in terms of line voltage and line current.   **(8)**

      b.   Define voltage reflection co-efficient and current reflection co-efficient with related equations.

(4)

  c. Explain how standing wave is generated? Calculate VSWR, if reflection co-efficient is 0.5.   **(4)**

Q.7   a. Explain the Impedance Transformation property of a quarter wave Transmission Line.   **(8)**

    b. What is a dominant mode? An air filled rectangular wave guide of dimensions 7 cms × 3.5 cms operates in the dominant TE_{10} mode. Find the following:
(i) cut-off frequency.
(ii) phase velocity of the wave at a frequency of 3.5 GHz.
(iii) guided wavelength at the same frequency.   **(8)**

Q.8   a. Explain Hertzian dipole. Calculate the directivity of a Hertzian dipole. Also show the variation of current and charge in Hertzian dipole.   **(10)**

    b. Compute the directivity of an antenna corresponding to the power density pattern function $f(\theta,\Phi) = \sin^2\theta . \cos^2\theta$
.   **(6)**

Q.9   Write short notes on:

        (i)   Critical frequency
        (ii)   Depth of penetration (or Skin depth)
        (iii)   Antenna Arrays
        (iv)   Rectangular cavity Resonator   **(4 × 4 = 16)**