[This question paper contains 5 printed pages.]

1409 *Your Roll No.* .....

B.Sc. (Hons.)/III **A**

ELECTRONICS – PAPER 3.4(XVIII)

(Electromagnetism and Antennas)

Time : 3 Hours *Maximum Marks : 38*

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt **five** *questions in all.*
Question **1** *is compulsory and carries* **ten** *marks.*
Use of scientific calculator is allowed.

1. Attempt any **five** :

(a) Derive the equation of continuity using the principle of conservation of charge. (2)

(b) Find $\vec{E}$ at (0, 3, 4)m in Cartesian coordinates due to a point charge $Q = 0.5\ \mu C$ at the origin. (2)

(c) For an anisotropic dielectric material characterized by the relationship.

$$\begin{bmatrix} D_X \\ D_Y \\ D_Z \end{bmatrix} = \begin{bmatrix} 4 & 2 & 2 \\ 2 & 4 & 2 \\ 2 & 2 & 4 \end{bmatrix} \begin{bmatrix} E_x \\ E_Y \\ E_Z \end{bmatrix}$$

P.T.O.

Find electric flux density $\vec{D}$ for

$$\vec{E} = E_0\left(\vec{a}_x + \vec{a}_Y + \vec{a}_Z\right) \quad (2)$$

(d) The $\vec{E}$-field of a uniform plane wave propagating in a dielectric medium is given by

$$\vec{E}(z, t) = \hat{a}_x\, 2\cos\left(10^6 t - z/\sqrt{3}\right)$$

$$- \hat{a}_y \sin\left(10^6 t - z/\sqrt{3}\right)$$

Determine the frequency, phase constant, wavelength and phase velocity. (2)

(e) Derive the relations for electric scalar potential and magnetic vector potential for time varying electromagnetic field. (2)

(f) Calculate radiation resistance of a $\lambda/16$ wire antenna in free-space. (2)

2. (a) Explain briefly how electrical images can be used in boundary condition problems. A point charge +q is placed at a distance 'd' from an infinite grounded conducting plane. Determine the electric field intensity at any point 'p' above the plane. (4)

(b) A air filled parallel plate capacitor is made of circular discs of area $2\,m^2$. The spacing between the discs is 0.1 m. If a voltage $20\cos(10^3 t)$ volts is applied across the capacitor plates, find the displacement current density and the magnetic field between the capacitor plates. (3)

3. (a) Write Maxwell's equations in the differential integral and phasor form along with equation of continuity and constitutive relations. (2)

(b) Derive the boundary conditions at an interface between two media for tangential and normal components of time varying electromagnetic field. (5)

4. (a) Starting from Maxwell's equations in conducting medium, obtain the wave equation for electric and magnetic fields. Also show that $\vec{E}$ and $\vec{H}$ vectors are not in phase. (3)

(b) Find the skin depth δ at a frequency of 2 MHz in aluminium, where $\sigma = 38.2$ MS/m and $\mu_r = 1$. (2)

(c) Define attenuation, phase constants and intrinsic impedance for the conducting medium. (2)

5. (a) Derive Fresnel's relations for reflection and refraction of plane electromagnetic wave at an interface between two dielectric media when $\vec{E}$ is perpendicular to the plane of incidence. (4)

(b) Derive the equation for Brewster's angle. Why it is also called as polarizing angle. (3)

6. (a) Derive the field equations for Transverse Electric (TE) mode in a rectangular waveguide. A rectangular waveguide acts as a high-pass filter. Explain. (4)

(b) A air filled rectangular waveguide of inside dimensions 7 × 3.5 cm operates in the TE_{20} mode. Determine the cutoff frequency. Find phase velocity of the wave at a frequency of 7 GHz in the guide. (3)

7. (a) Derive the expression for electric and magnetic fields of a Hertzian dipole antenna and explain the terms $\frac{1}{r}$, $\frac{1}{r^2}$ and $\frac{1}{r^3}$. (4)

(b) Write down the electric and magnetic field expressions in the far-field region hence forth derive the power radiated by the Hertzian dipole antenna. (3)

8. Write short note on any **three** :

(a) Horn Antenna

(b) Skip distance and Virtual Height

(c) Surface wave propagation

(d) Radiation resistance and directivity (2,2,3)

Notes :

$\vec{a}_x, \vec{a}_Y, \vec{a}_Z$ are unit vectors in X, Y & Z-directions.

Physical Constants :

for free – space

$\epsilon_0 = 8.854 \times 10^{-12}$ Farad/meter

$\mu_0 = 4\pi \times 10^{-7}$ Henry/meter

$C = 3 \times 10^8$ m/sec