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B. Tech

CPEE 5307

FIFTH SEMESTER EXAMINATION – 2005

ELECTROMAGNETIC THEORY

Full Marks – 70

Time : 3 Hours

The figures in the right-hand margin indicate marks.

Answer Question No. ***1*** *which is compulsory and any* ***five*** *of the remaining questions.*

1. Answer the following : 2×10

   (i) Transform the vector $\vec{B} = ya_x - xa_y + za_z$ into cylindrical co-ordinates.

   (ii) Two infinitely long line charges are separated by a distance 'd'. Draw the equipotential surfaces.

   (iii) Show that the capacitance of an isolated metallic sphere of radius R is $4\pi \epsilon_0 R$ farads.

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(iv) Two current elements $I_1 \vec{dl}_1$ and $I_2 \vec{dl}_2$ are separated by a distance R. Write the expression for the magnetic force experienced by each current element due to the other.

(v) Write the electromagnetic boundary conditions on the surface of a perfect conductor.

(vi) A plane uniform electromagnetic wave having electric field strength E = 1V/m at frequency 300 MHz is incident normally on a copper slab having conductivity $\sigma = 5.8 \times 10^7$ mhos/m. Determine the depth of penetration δ .

(vii) A small loop of conducting wire carries a current I. Draw the magnetic lines of force due to it.

(viii) An a. c. voltage $V = V_m \sin\omega t$ is applied across a capacitor. Show that the displacement current through the capacitor is equal to the conduction current I flowing through connecting wire.

(ix) Show that in a uniform linear array radiating broadside, the first secondary maximum (1st side lobe level) appears – 13.5 dB below the principal maximum (main lobe).

(x) Define polarization of an electromagnetic wave. Under what conditions the wave is said to be linearly polarized ?

2. Four identical 3-nano columb charges are located at P_1 (1, 1, 0), P_2 (–1, 1, 0), P_3 (–1, –1, 0) and P_4 (1, –1, 0) in a rectangular co-ordinate frame. Find the electric field at P (1, 1, 1). 10

3. Two co-axial conducting cylinders of radius 2 cms and 5 cms have a length of 1 m. The region between the cylinders is filled with a dielectric of $\epsilon_{r1} = 2$ from r = 2 cms to r = 4 cms and $\epsilon_{r2} = 3$ from r = 4 cms to r = 5 cms. Find the capacitance between the cylinders. Derive the formula you use. 10

4. (a) Develope the concept of vector magnetic potential $\vec{A}$. Derive the wave equation interms of A. 5

(b) A current element $I\vec{dl}$, located at the origin of a rectangular co-ordinate system is lying along the z-direction. Using vector magnetic potential $\vec{A}$ find the magnetic field intensity $\vec{H}$ at an observation point P (ρ, ϕ, z). 5

5. (a) List all the Maxwell's equations for time varying electromagnetic field. Write also the equation of continuity. Give a physical interpretation of the equation containing displacement current density. 5

(b) A uniform plane electromagnetic wave propagating in free space is given by

$$\vec{E} = 37.7 \cos\left(9p\times10^{7} t + 0.3py\right) \vec{a}_x \text{ V / m}$$

Find its (i) Phase shift constant β, (ii) Wave-

length λ, (iii) Phase velocity v_p and (iv) Whether it is a forward or backward propagating wave. 5

6. A vertically polarized uniform plane wave is incident at an angle of 45° from air on a dielectric slab of $\epsilon_r = 4$, $\mu_r = 1$ and $\sigma = 0$. The incident field strength is 100 mv/m at 10 MHz. Calculate the power transmitted to the dielectric slab. Is there an angle of incidence for which there will be no reflection ? 10

7. Derive an expression for the electric field intensity for a halfwave centre fed dipole antenna. Draw its radiation pattern. Draw also the radiation pattern of a quarterwave monopole antenna. 10

8. Write short notes on any *two* : 5×2

(a) Principal of Pattern Multiplication

(b) Poynting vector and Power flow

(c) Biot-Savart law

(d) Method of Images

(e) Hysteresis loop of a magnetic material.
