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No. of Printed Pages—5 **EC—401**

B. TECH.

FOURTH SEMESTER EXAMINATION, 2002-2003

ELECTROMAGNETIC FIELD THEORY

Time : 3 Hours *Total Marks : 100*

Note : (1) Attempt **ALL** the questions.
(2) All questions carry equal marks.

1. Attempt any FOUR of the following :— **(5×4=20)**

(*a*) What do you mean by Scalar and Vector Fields ? Show the difference between the two.

(*b*) What is the importance of surface integral with reference to electromagnetic fields ? Explain with one example. Use the cylindrical co-ordinate system to find the area of a curved surface on the right circular cylinder of radius 2 m, height 8 m and $45^\circ \leq \Phi \leq 90^\circ$.

(*c*) What is Stokes' Theorem ? State and prove it.

(*d*) What is Gauss's Law ? State and prove it.

(*e*) State Divergence Theorem and physically interpret the equivalence of the L.H.S. and the R.H.S. terms.

(*f*) Find the rate at which the Scalar function

$V = r^2 \sin 2\Phi$ increases in the

(*i*) Z direction

(*ii*) Φ direction.

Evaluate it at $r = 2$ m and $\Phi = 45^\circ$.

2. Attempt any FOUR of the following :— (5×4=20)

(a) Discuss the method of images to plain boundaries problems.

(b) What is understood by boundary conditions in static electric field ? Why are the equi-potential surfaces perpendicular to the electric flux lines ?

(c) Three capacitors C_1, C_2 and C_3 are charged (as shown in fig. 1) by a voltage source V by closing the switch S.

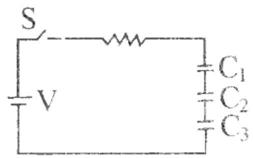

Fig. 1

Will the charge on the plates of the capacitors be
(i) equal or
(ii) non-equal ?

Explain your answer physically.

(d) If $V = x - y + xy + 2z$ volts, then find the electrostatic energy stored in a cube of side 2 m centered at the origin.

(e) Consider two concentric spheres of radii a and b, $a < b$. The outer sphere is kept at a potential V_0 and the inner sphere at zero potential. Solve Laplace's equation in spherical co-ordinates to find the potential and electric field in the region between the two spheres.

(*f*) Find the capacitance of the system shown in fig. 2.

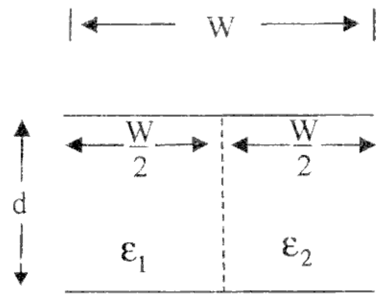

Fig. 2

The length of each conducting plate is L.

3. Attempt any TWO of the following :— **(10×2=20)**

(*a*) How is magnetic flux density related to the magnetic vector potential ? Find out the magnetic vector potential in the vicinity of a very long straight wire carrying a current *I*. Hence find the magnetic field strength.

(*b*) (*i*) Show that the stored energy density in a magnetic field of strength *H* is $\frac{1}{2}\mu H^2$.

(*ii*) Explain the Faraday's Law of Induction.

(*c*) Prove that the normal component of B is continuous across a boundary between two isotropic and homogeneous materials with permeabilities μ_1 and μ_2 . What can be said about Hn_1 and Hn_2 in the above case ?

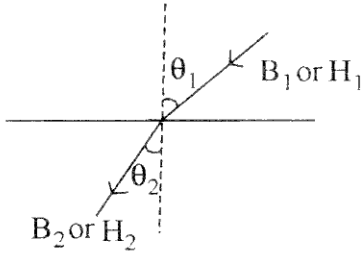

Fig. 3

In, fig. 3 shown above

$B_1 = 2\,Ux - 3\,Uy + 2\,Uz$, is incident on the xy plane ($z = 0$). The medium at $z > 0$ has $\mu_1 = 4\,\mu_0$ and $z < 0$ has $\mu_2 = 7\,\mu_0$. Find B_2.

Ux, Uy and Uz indicate unit vectors in the respective directions.

4. Attempt any TWO of the following :— **(10×2=20)**

(*a*) Derive the equation of continuity for time varying fields and point out the inconsistency of Ampere's law for time varying fields.

(*b*) A uniform plane wave, moving in free space is given by $E_y = 50 \cos(10^8 t + \beta x)$.

(*i*) Find the direction of propagation.

(*ii*) Calculate β.

(*iii*) Find time it takes to travel a distance $\frac{\lambda}{2}$.

(*iv*) Find expression for magnetic intensity.

(*c*) What is understood by polarization of EM waves ? Explain linear, elliptical and circular polarization with appropriate figures.

Show that a linearly polarised wave can be interpreted as a combination of two circularly polarised waves of equal magnitude and angular velocities, rotating in opposite directions.

5. Attempt any TWO of the following :— **(10×2=20)**

(*a*) Derive expressions for sending end-voltage and current along a transmission line in terms of receiving end-quantities for a lossless line.

(*b*) What are the techniques used for impedance matching on transmission lines ? Discuss one technique in detail.

(*c*) A telephone line has

$R = 30\ \Omega/\text{km}$

$L = 100\ \text{mH/km}$

$G = 0$

$C = 20\ \mu F/\text{km}$ at 1 KHz .

Obtain

(*i*) the characteristic impedance of the line,

(*ii*) the propagation constant.

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