Name : .....

Roll No. : .....

Invigilator's Signature : .....

2013
FIELD THEORY

Time Allotted : 3 Hours *Full Marks :* 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following questions : $10 \times 1 = 10$

   i) Where surface $r = 2$ and $z = 2$ intersect in cyl. coordinates

      a) an infinite plane b) a suminfinite plane

      c) a cylinder d) a circle.

   ii) Gradient of a scalar field is expressed as

      a) Outward flux of a vector field per unit volume as the volume about the point tends to zero

      b) Circulation of a vector field per unit area tends to zero

      c) Maximum rate of increase of scalar function at a point

      d) Gradient of divergence of vector field minus the curl of the vector field.

iii) For a good plane conductor, skin depth varies

a) directly as square root of frequency

b) inversely as square root of frequency

c) directly as a function of frequency

d) inversely with frequency.

iv) Energy density in an electrostatic field is

a) $\frac{1}{2}(\varepsilon E^2)$ b) (εE^2)

c) $2(\varepsilon E^2)$ d) $\frac{1}{2}(\varepsilon E)$.

v) The value of intrinsic impedance of free space is

a) 50 ohm b) 72 ohm

c) 120 ohm d) 377 ohm.

vi) Electric field inside a uniformly charged sphere

a) varies linearly with the distance from the centre

b) remains constant

c) varies inversely with the distance from the centre

d) is zero.

vii) Two thin parallel wires carry currents along the same direction. The force experienced by one due to the other is

a) Parallel to the lines

b) Perpendicular to the lines and attractive

c) Perpendicular to the lines and repulsive

d) Zero.

viii) Impedance inversion may be obtained with a

a) half wave line b) quarter wave line

c) short circuited stub d) open circuited stub.

ix) Curl of a gradient of a scalar function results in

a) nonzero scalar b) nonzero vector

c) zero vector d) periodic function.

x) The direction of propagation of an electomagnetic wave is

a) independent of the direction of the associated electric field

b) only perpendicular to the direction of associated electric field

c) only perpendicular to the direction of associated magnetic field

d) perpendicular to both the electric and magnetic field.

xi) A transmission line is said to be distortion-less if

a) $\frac{R}{G} = \frac{C}{L}$ b) $\frac{R}{G} = \frac{L}{C}$

c) $RG = LC$ d) $R = 0$.

xii) At the boundary of two media of permeability μ_1 and μ_2 the boundary conditions is satisfied by

a) the normal component of the magnetic field strength *H* which is continuous

b) the normal component of the flux density *B* which is continuous

c) the tangential component of the flux density *B* which is continuous

d) the tangential component of the field strength *H* which is continuous.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. Write the mathematical expression for the Law of conservation of charge. Hence obtain the equation of continuity. 1 + 4

3. What do you mean by 'skin effect' ?

Calculate the skin depth in Cu at 100 MHz. Given $\sigma = 5 \cdot 8 \times 10^{-7} \text{S/m}$. Compare the magnitude of the field intensity at this depth with its initial value. Determine also the surface resistance at this frequency. 1 + 4

4. Explain what is meant by a uniform plane wave. A uniform plane wave has a wavelength of 2 cm in free space and 1 cm in a perfect dielectric (σ = 0, and $\mu_r = 1$). Determine the relative permittivity of the medium. 2 + 3

5. Draw the equivalent circuit of a transmission line in terms of the line parameters. Give the adequate reasoning for adopting such an equivalent circuit. 2 + 3

6. Explain the physical significances of the following : $2\frac{1}{2} + 2\frac{1}{2}$

   a) Gradient of a field.

   b) Curl of a vector field.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Obtain an expression for the energy density in an electrostatic field. 6

   b) Find the expression of total force on the charge Q in the presence of both electric and magnetic field. 5

   c) It is found that $\vec{E} = 60\ \vec{a}_x + 20\ \vec{a}_y + 30\ \vec{a}_z$ mV/m at a particular point on the interface between air and a conducting surface. Find $\vec{D}$ and ρ at that point. 4

8. a) Write down the Maxwell's equation of electromagnetic field. 4

   b) Obtain the Poynting's theorem for the conservation of energy in an electromagnetic field and discuss the physical meaning of each term in resulting equation. 6

   c) In free space the electric field vector is given by E = 100 cos ($\omega t + 4\pi/3x$) a_z V/m, where $\omega = 2\pi f$ and f = 200 MHz. Determine the direction of power flow and the time average power crossing the surface area bounded by y = 2m, y = 0, z = 2m and z = 0. 5

9. a) State and explain Biot-Savart Law. Derive an expression for the force between two parallel wires carrying currents in the same direction. 5

b) What do you mean by polarization of a uniform plane wave ?

Determine the polarization of the following uniform plane wave :

$E = 1\cos\ (\omega t + \beta z)\ a_x - 2\sin(\omega t + \beta z - 45^\circ)\ a_y$ 1 + 4

c) In a material for which σ = 5·0 S/m, and $\varepsilon_r = 1$, the electric field intensity is 250 sin $(10^{10} t)$ V/m. Find the conduction and displacement current densities. Determine the frequency when these two currents will be equal in magnitude. 5

10. a) Define characteristic impedance of a transmission line. Explain the formation of standing wave pattern on transmission line. 2 + 3

b) Deduce the relation between the reflection coefficient and VSWR. 5

c) A transmission line of characteristic impedance 50 ohm is terminated by resistor of 100 ohm. What will be the VSWR in the line ? Calculate the impedances at the voltage minimum and maximum position. 5

11. Write short notes on any *three* of the following : 3 × 5

a) Uniqueness Theorem

b) Boundary conditions for electrostatic fields

c) Propagation constant

d) Quarter Wave Transmission Line

e) Vector Magnetic Potential.