MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

Paper Code : EE-302

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 : $10 \times 1 = 10$

   i) Gradient of a scalar function results in

      a) vector function

      b) scalar function

      c) periodic function

      d) peak function.

   ii) A charged particle moving in a magnetic field experiences a force which is maximum when

      a) the velocity of the particle is parallel to the field

      b) the velocity of the particle is perpendicular to the field

      c) the velocity of the particle is at an angle 45° with respect to the field

      d) the velocity of the particle is at an angle 60° with respect to the field.

   iii) Electrostatic field is

      a) Solenoidal

      b) Irrotatiosial

      c) Conservative

      d) Both irrotational and conservative.

   iv) In cylindrical co-ordinate, dV is given by

      a) $\rho d\rho\ d\phi\ dz$

      b) $\rho d\ \phi\ d\rho\ d\theta$

      c) $d\rho\ d\phi\ dz$

      d) $dx\ dy\ dz$.

v) A field can exist if it satisfies

a) Gauss's law

b) Faraday's law

c) Coulomb's law

d) all Maxwell's equations

vi) If the number of turns in a solenoid is doubled and its radius is halved, then its self inductance

a) is doubled b) becomes four times

c) remains same d) becomes half.

vii) At the boundary of two media of permeability μ_1 and μ_2, the boundary condition satisfied is

a) the normal component of magnetic field strength $\vec{H}$ is continuous

b) the normal component of magnetic flux density $\vec{B}$ is continuous

c) the tangential component of magnetic flux density $\vec{B}$ continuous

d) the tangential component of magnetic field strength $\vec{H}$ continuous.

viii) To apply Gauss's law for finding electric field, the Gaussian surface should be chosen in such a way that the field is ..... to the surface.

a) perpendicular

b) tangential

c) either perpendicular or tangential

d) parallel.

ix) The magnetic field at any point on the axis of a current-carrying circular coil will be

a) perpendicular to the axis

b) parallel to the axis

c) at any angle 45° with axis

d) zero.

x) Stokes' theorem transforms

a) line to volume integral

b) volume to surface integral

c) surface to volume integral

d) surface to line integral.

xi) In good conductors, the phases of $\vec{E}$ and $\vec{H}$ differ by

a) 180° b) 90°

c) 0° d) 45°.

xii) The point P (1, 3, 5) in the Cartesian co-ordinate system has been transformed to cylindrical co-ordinate system. The co-ordinate of point P is

a) 3·16, 71·565°, 5

b) 3·162, 5·71, 71·565°

c) 5·916, 32·11°, 3·162

d) 5·916, 3·162, 32·11°.

GROUP – B

(Short Answer Type Questions)

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

2. Find electric field intensity due to a uniformly charged infinite plane sheet with surface charge density σ c/m^2.

3. Given $\phi = xy + yz + xz$, find $\Delta\phi$ at point (1, 2, 3) and the directional derivative of ϕ at the same point in the direction toward the point (3, 4, 4). $2 + 3$

4. Derive an expression of inductance per unit length of a co-axial transmission line carrying current I. Both the conductors are hollow.

5. A square coil with loop area 0·01 sq.m and 50 turns is rotated about its axis in the anti-clockwise direction at right angles to a uniform magnetic field $\vec{B}$ = 1·0 T. Calculate the instantaneous value of the *emf* induced in the coil when its plane is in the plane of the field. Speed of rotation = 1000 rpm.

6. Prove that the poynting vector gives the power flow per unit area of cross-section at a point in the medium.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. a) State Biolt-Savart law.

b) A finite length of wire is carrying a current I. Find the magnetic field intensity due to this current of a point, which is r m away from the wire.

c) Thin ring of radius 5 cm is placed on z = 1cm so that its centre is at (0, 0, 1) cm. If the ring carries 50 mA along $\vec{a}_\phi$, find $\vec{H}$ at (0, 2, –1) cm.

8. a) Derive the propagation constant and characteristic impedance for a lossless transmission line from the transmission line equations.

b) An open wire telephone line has $R = 10\Omega$ per km, $L = 0{\cdot}0037$ henry per km, $C = 0{\cdot}0083 \times 10^{-6}$ farad per km and $G = 0{\cdot}4 \times 10^{-6}$ ohm per km. Determine z_0, γ, α and β at 1000 Hz.

c) Draw the equivalent circuit of a transmission line. How to achieve distortionless condition on the line ? Derive necessary conditions. 5 + 4 + 6

9. a) Why is electrostatic field called conservative field ?

b) 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 interface between air and a conducting surface. Find $\vec{D}$ and ρ_s at that point.

c) Deduce an expression of energy density in electrostatic field. 4 + 5 + 6

10. a) Starting with Maxwell's equations, derive the wave equation in magnetic field for a linear homogeneous isotropic medium.

b) An *EM* wave travels in free space with electric field component $E = (10ay + 5az)\cos(\omega t + 2y - 4z)$ V/m. Determine (i) ω & λ (ii) the magnetic field component (iii) the time average power in the wave.

c) What is perpendicular and parallel polarization ?

4 + 7 + 4

11. a) What do you mean by transformer *emf* and motional *emf* ? State the differences between them.

2 + 2 + 2

b) Prove that $\vec{J}_d = \frac{\partial \vec{D}}{\partial t}$ where $\vec{J}_d$ is the displacement current density. 5

c) Given the magnetic vector potential $\vec{A} = -\rho^2/4\vec{a}_z$ Wb/m^2, calculate the total magnetic flux crossing the surface defined by $\phi = \pi/2$, $1 \le \rho \le 2$m, $0 \le z \le 5$m. 4

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

a) General procedures for solving Poisson's and Laplace's equations

b) Helmholtz's theorem

c) Maxwell's equations

d) Method of images.