Name : .....

Roll No. : .....

Invigilator's Signature: .....

CS/B.Tech (EE-New)/SEM-4/EE-402/2010

2010

ELECTROMAGNETIC 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) The vector identity of $\nabla \times (\nabla \times \vec{A})$ is

a) $\nabla (\nabla . \vec{A}) - \nabla^2 \vec{A}$

b) $\nabla . (\nabla \times \vec{A}) - \nabla^2 \vec{A}$

c) $\nabla \times \vec{A} - \nabla^2 \vec{A}$

d) $\nabla \times (\nabla . \vec{A}) - \nabla^2 \vec{A}$.

ii) The expression of $\nabla V(r, \theta)$ in $r - \theta$ co-ordinate is

a) $\vec{i}\frac{\partial v}{\partial x} + \vec{j}\frac{\partial v}{\partial y} + \vec{k}\frac{\partial v}{\partial z}$

b) $\frac{\partial v_x}{\partial x} + \frac{\partial v_y}{\partial y} + \frac{\partial v_z}{\partial z}$

c) $\frac{\partial v}{\partial r}\vec{u}_r + \frac{\partial v}{r d\theta} + \vec{u}_\theta$

d) $\frac{\partial v}{\partial r}\vec{u}_r + \frac{\partial v}{\partial \theta}\vec{u}_\theta$

iii) In a perfect dielectric, the wavelength of E.M. wave is

a) $\lambda = \frac{2\pi}{\sqrt{\mu\epsilon}}$ b) $\lambda = \frac{1}{\sqrt{\mu\epsilon}}$

c) $\lambda = \frac{\omega}{\sqrt{\mu\epsilon}}$ d) $\lambda = \frac{2\pi}{\omega\sqrt{\mu\epsilon}}$.

where μ = permeability of the medium

ϵ = permittivity of the medium

ω = angular frequency.

iv) Relation among magnetic vectors $\vec{B}$, $\vec{M}$ & $\vec{H}$ is

a) $\vec{B} = \mu_o \vec{H} + \vec{M}$

b) $\vec{B} = \mu \vec{H} + \vec{M}$

c) $\vec{H} = \mu \vec{B} + \vec{M}$

d) $\vec{H} = \frac{\vec{B}}{\mu_o} - \vec{M}$.

v) The potential V due to an electric dipole located at a distance 'r' from the dipole

a) varies directly as r

b) varies inversely as r

c) varies inversely as r^2

d) varies inversely as r^3.

vi) The integral $\oint \vec{E} \cdot d\vec{\rho} = 0$, if the electric field $\vec{E}$ is caused by

a) a static charge

b) a time varying magnetic field

c) moving charge

d) magnetic dipole.

vii) One tesla is equal to

a) 10^6 gauss b) 1 gauss

c) 10^{-4} gauss d) 10^4 gauss.

viii) Electric potential & electric field intensity inside a spherical shell are

a) zero & constant respectively

b) both inversely proportional to radius

c) constant & zero respectively

d) zero & zero respectively.

ix) The direction of force on a conductor carrying current in the positive *Y*-axis & placed in magnetic field directed in positive *X*-axis, will be

a) positive *Z*-axis b) negative *Z*-axis

c) negative *X*-axis d) negative *Y*-axis.

x) A Gaussian surface is

a) an open surface

b) a closed surface

c) a semi-open surface

d) all of these.

xi) Gradient of scalar function results in

a) vector function b) scalar function

c) periodic function d) peak function.

xii) Poynting vector has the unit

a) $W\ m^{-2}$ b) $J\ s^{-1}$

c) W d) $J\ m^{-2}$.

GROUP – B
(Short Answer Type Questions)

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

2. Develop an expression of $\vec{E}$ at (0, 0, 5) *m* due to $Q_1 = 0{\cdot}35\ \mu C$ at (0, 4, 0) *m* & $Q_2 = -0{\cdot}55\ \mu C$ at (3, 0, 0) *m*.

3. Given an electric flux density $\vec{D} = 2x\ \vec{a}_x + 3\ \vec{a}_y$ (C / m^2), determine the net flux crossing the surface of a cube 2 m on an adge centered at origin. (the edges of the cube are parallel to the co-ordinate axis).

4. Find $\vec{H}$ on the axis of a circular loop of radius *a*.

5. Find the force per unit length on two long, straight, parallel, conductors, if each carries a current of 10 A in the same direction & the separation distance is 0·2 m.

6. Differentiate between magnetic scalar potential & magnetic vector potential.

7. State how transformer *emf* differs from motional *emf*. Derive the necessary expressions. 2 + 3

GROUP – C
(Long Answer Type Questions)

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

8. a) Show that the electric field is conservative. Derive the relation $\vec{E} = -\vec{\nabla}V$. The symbols has usual meaning. 3 + 3

   b) State divergence theorem. Find the divergence of the electric flux density $\vec{D}$. Why is the divergence of the magnetic flux density $\vec{B}$ always zero ? 2 + 5 + 2

9. a) State & explain Ampere's law of magnetostatics. Explain how this law is modified by introduction of displacement current. 3 + 5

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

10. a) Obtain the Poynting theorem for conservation of energy in electromagnetic fields & discuss the physical meaning of each term in the resulting equation. 8

    b) An EM wave travels in free space with electric field component

    $$E = \left(10\,\vec{a}_y + 5\,\vec{a}_z \right) \cos\left(\omega t + 2y - 4z \right) \text{ V/m}.$$

    Determine :

    (i) ω & λ

    (ii) the magnetic field component

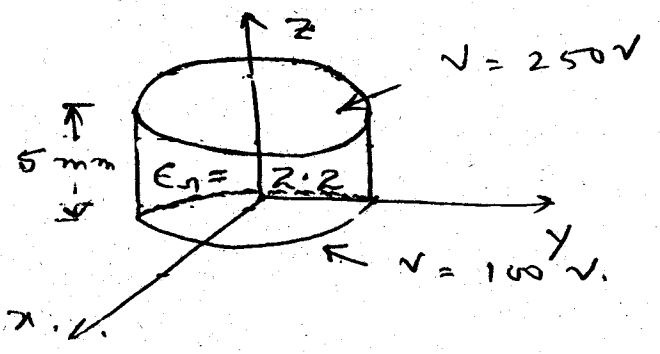
    (iii) the time average power in the wave. 2 + 2 + 3

11. a) Write & interpret two Maxwell's equations relating to $\vec{B}$. 6

b) Explain the importance of propagation constant (γ) & charactertic impedance $\left(z_0 \right)$ of a transmission line. State the conditions for lossless & distortionless transmission line. 6

c) Why is it desirable to achieve an impedance match in a transmission line ? 3

12. a) The parallel conducting disks shown in the figure are separated by 5 mm and contain a dielectric for which $\epsilon_r = 2{\cdot}2$. Determine the charge densities on the disk.



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b) Explain the method of images for solving electrical problems. 5

c) Write a note on continuity equation. 3