Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.TECH (EE(O))/SEM-4/EE-402/2012

2012

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) If a vector field Q is solenoidal, which of the following is true ?

a) $\oint Q.dl = 0$ b) $\oint Q.ds = 0$

c) $\nabla \times Q = 0$ d) $\nabla^2 Q = 0$.

ii) An electric potential field is produced by two point charges 1μC and 4μC located at (–2, 1, 5) and (1, 3, –1). The energy stored in the field is

a) 2·57 mJ b) 5·14 mJ

c) 10·28 mJ d) none of these.

iii) Plane z = 10 m carries charge 20 nC/m². The electric field intensity at the origin is

a) $-10\ \hat{k}$ V/m b) $-18\pi\hat{k}$ V/m

c) $-72\pi\hat{k}$ V/m d) $-360\pi\hat{k}$ V/m.

iv) Which of the following is zero ?

a) grad div b) curl grad

c) div grad d) curl curl.

v) For a Cartesian point (–3, 4, –1), which of the following is correct ?

a) $\rho = -5$ b) $r = \sqrt{26}$

c) $0 = \tan^{-1}\left(\frac{5}{1}\right)$ d) $\varphi = \tan^{-1}\left(\frac{4}{3}\right)$.

vi) Which of the following potentials does not satisfy Laplace's equations ?

a) $V = 2x + 5$ b) $V = \frac{10}{r}$

c) $V = r\cos\varphi$ d) $V = 10xy$.

vii) Two identical coaxial circular coils carry the same current but in opposite directions. The magnitude of the field B at a point on the axis midway between the coils is

a) zero

b) the same as that produced by one coil

c) twice as that produced by one coil

d) half that produced by one coil.

viii) Plane y = 0 carries a uniform current of $30\hat{k}$ mA/m. At (1,10, –2) the magnetic field intensity is

a) $-15\hat{i}$ mA/m b) $15\hat{i}$ mA/m

c) $477 \cdot 5\hat{j}$ mA/m d) none of these.

ix) The electric field component of a wave in free space is $E = 10\cos(10^7 t + kz)\hat{j}$ V/m. It can be inferred that

a) the wave propagates along $\hat{j}$

b) the wavelength $\lambda = 188 \cdot 5$ m

c) the amplitude is 10 V/m

d) both (b) and (c) are correct.

x) What is the major factor for determining whether the medium is a free space, lossless dielectric, lossy dielectric or a good conductor ?

a) Attenuation constant

b) Constitutive parameters (σ, ε, μ)

c) Loss tangent

d) Reflection coefficient.

xi) Which of the following does not satisfy the wave equation ?

a) $50e^{i\omega(t-3z)}$ b) $\sin\omega(10z+5t)$

c) $(x+2t)^2$ d) $\cos^2(y+5t)$.

xii) The poyting vector physically denotes the power density leaving or entering a given volume in a time varying field.

a) True b) False.

GROUP – B

(Short Answer Type Questions)

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

2. An EM wave travels in free space with electric field component, $E = 100e^{i(0.8669+0.5z)}\,\hat{i}$ V/m. Determine

   a) ω and λ

   b) the magnetic field component

   c) the time average power. 2 + 2 + 1

3. a) A magnetostatic field never delivers energy to a charged particle moving in that field. Explain.

   b) A charged particle of mass 2 kg and charge 3C starts at appoint (1, –2, 0) with velocity $4\hat{i}+3\hat{k}$ m/s in an electric field $12\hat{i}+10\hat{j}$ V/m. At time t = 1 s, determine

      i) the acceleration of the particle

      ii) its velocity

      iii) its K.E. 2 + 3

4. State Ampere's circuital law and hence find out $\nabla \times H$. Find the magnetic field intensity due to an infinite sheet of current. 2 + 3

5. a) What is uniqueness theorem ? Give the general procedures to find the solution for Laplace's and Poisson's equations.

b) In a one dimensional device, the charge density is given by $\rho = \rho_0 x / a$. If E = 0 at x = 0 & V = 0 at x = a. Find V and E. 2 + 3

GROUP – C

(Long Answer Type Questions)

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

6. a) Express gradient and divergence operator in cylindrical coordinate system.

b) Prove that $\oint \nabla T . \mathrm{d}l = 0$, where T is any scalar function.

c) State and explain the fundamental theorem of divergence and hence show $\nabla . E = \rho / \varepsilon_0$. 5 + 5 + 5

7. a) Find out the expression for electric field intensity due to an infinite sheet of uniform charge density σ in the x-y plane and hence show that the intensity is independent of the distance from the sheet.

b) Derive the expression for electrostatic energy stored in a continuous distribution of charge. 8 + 7

8. a) Determine the charge densities due to each of the following electric flux densities :

i) $D = (r\sin\varphi)\hat{r}(3r\cos\varphi)\hat{\varphi} + (z^2)\hat{k}$

ii) $D = (2\cos\theta/r^3)\hat{r} + (\sin\theta/r^3)\hat{\theta}$ C/m^2

b) A spherical charge distribution is given by

$$\rho = \begin{cases} \rho_0 r/a & , r < a \\ 0 & , r > a \end{cases}$$

Find V and E everywhere. 7 + 8

9. a) Derive the boundary conditions for E and D for

i) Dielectric - Dielectric interface

ii) Dielectric - Conductor interface.

b) Derive the magnetic boundary conditions.

c) Using Biot-Savart law find the magnetic field intensity due to a straight filamentary conductor. Also find the value when the conductor is infinitely long. 5 + 4 + 6

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