



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) $\oint Q \cdot dl = 0$ b) $\oint Q \cdot ds = 0$

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

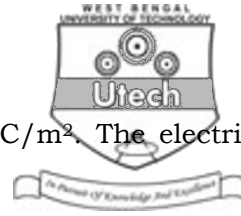
ii) An electric potential field is produced by two point charges $1\mu\text{C}$ and $4\mu\text{C}$ located at $(-2, 1, 5)$ and $(1, 3, -1)$. The energy stored in the field is

a) 2.57 mJ b) 5.14 mJ

c) 10.28 mJ d) none of these.

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[Turn over



- iii) Plane $z = 10$ m carries charge 20 nC/m^2 . The electric field intensity at the origin is

- a) $-10 \hat{k} \text{ V/m}$ b) $-18 \pi \hat{k} \text{ V/m}$
c) $-72\pi \hat{k} \text{ V/m}$ d) $-360\pi \hat{k} \text{ V/m}.$

- 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) $\phi = \tan^{-1}\left(\frac{4}{3}\right).$

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

- a) $V = 2x + 5$ b) $V = \frac{10}{r}$
c) $V = r \cos \phi$ 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) $477.5\hat{j}$ mA/m
- d) none of these.

ix) The electric field component of a wave in free space is

$$E = 10 \cos(10^7 t + kz) \hat{j} \text{ V/m. It can be inferred that}$$

- a) the wave propagates along \hat{j}
- b) the wavelength $\lambda = 188.5$ 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.

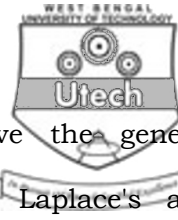


GROUP – B

(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 × 15 = 45

6. a) Express gradient and divergence operator in cylindrical coordinate system.
- b) Prove that $\oint \nabla T \cdot d\mathbf{l} = 0$, where T is any scalar function.
- c) State and explain the fundamental theorem of divergence and hence show $\nabla \cdot \mathbf{E} = \rho/\epsilon_0$. 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) $D = (2 \cos \theta / r^3) \hat{r} + (\sin \theta / r^3) \hat{\theta} \text{ C/m}^2$

- 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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