

Name :

Roll No. :

Invigilator's Signature :

CS/B.Tech (EE-N)/SEM-4/EE-402/2011

2011

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 × 1 = 10

- i) The Gauss's law of electrostatics is expressed as

a) $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$

b) $\nabla^2 \psi = -\frac{\rho}{\epsilon_0}$

c) $\vec{E} = -\nabla \psi$

d) $\oint_s \vec{D} \cdot d\vec{s} = \int_v \nabla \cdot \vec{D} d\tau$.

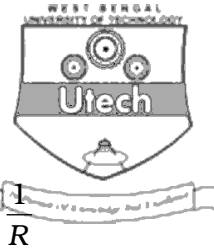
- ii) A Gaussian surface for application is

a) a closed surface

b) a symmetrical closed surface

c) a semi-closed surface

d) any surface.



iii) Capacitance of the earth of radius R is

- a) $2\pi \epsilon_0 R$ b) $4\pi \epsilon_0 \frac{1}{R}$
- c) $\frac{4}{3}\pi \epsilon_0 R^3$ d) $4\pi \epsilon_0 R$.

iv) Which of these statements is not characteristic of a static magnetic field ?

- a) it is conservative
- b) it is solenoidal
- c) it has link & sources
- d) magnetic flux lines are always closed.

v) Electric field in a region containing space charges can be found using

- a) Laplace's equation b) Poisson's equation
- c) Coulomb's law d) Helmholtz equation.

vi) In a transmission line, electromagnetic energy is transported by

- a) the flow of electrons
- b) the flow of electrons & holes
- c) the associated electric & magnetic field
- d) electric field only.

10. *Pharmaceuticals* (10%)

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- xi) Which is the major factor for determining whether a medium is free space, lossless dielectric, loss dielectric or good conductor ?
- a) attenuation constant
 - b) constitutive parameters (α , ϵ , μ)
 - c) loss tangent
 - d) reflection co-efficient.
- xii) Which of these functions do not satisfy the wave equation ?
- a) $\sin x \cos t$
 - b) $\cos^2(y + 5t)$
 - c) $(x + 2t)^2$
 - d) $\sin w(10z + t)$.

GROUP – B
(Short Answer Type Questions)

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

2. Find the divergence and curl of the following vectors
 $\vec{A} = x^2yz \vec{ax} + xz \vec{az}$.
3. Given point $P (- 2, 6, 3)$. Express P in cylindrical and spherical co-ordinates.
4. A point charge of 30 nc is located at the origin while plane $y = 3$ carries charge 10 nc/m^2 . Find \vec{D} at $(0, 4, 3)$.



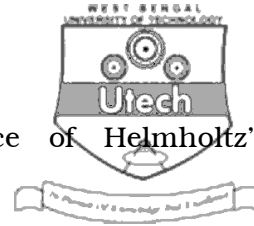
5. Two dipoles with dipole moments $-5\vec{a}_z$ nc/m & $9\vec{a}_z$ nc/m are located at points $(0, 0, -2)$ & $(0, 0, 3)$ respectively. Find the potential at the origin.
6. A thin ring of radius 5 cm is placed on plane $z = 1$ cm so that its centre is at $(0, 0, 1)$ cm. If the ring carries 50 mA along $\alpha\phi$ find \vec{H} at $(0, 0, -1)$ cm.
7. A transmission line operating at 500 MHz has $z_0 = 80\Omega$, $\alpha = 0.04$ Np/m, $\beta = 1.5$ rad/m. Find the line parameters R , L , G , & C .

GROUP – C

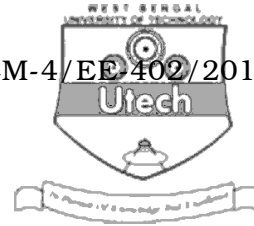
(Long Answer Type Questions)

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

8. a) Derive the following equations
- $\nabla \times \vec{H} = J$
 - $\nabla \cdot \vec{B} = 0.$
- b) A solenoid of length ' l ' and radius ' a ' consists of N turns of wire carrying current I . Show that at point P along its axis $\vec{H} = \frac{nI}{2}(cm \theta_2 - cm \theta_1) \vec{a}_z$ where $n = N/l$ & θ_1 & θ_2 are the angles subtended at P by the end turns.
- c) Determine the self inductance of a co-axial cable of inner radius ' a ' & outer radius ' b '. $4 + 6 + 5$



9. a) State and explain the significance of Helmholtz's theorem.
- b) Write Lorentz force equation. Hence obtain the expression of force acting on a straight conduction of length 'L' in a uniform magnetic field \vec{B} .
- c) Find the force on a straight conductor of length 0.20 m carrying a current of 5.0 A in the \vec{az} direction where the field in $\vec{B} = 4 \times 10^{-3} (\vec{ax} + \vec{ay})$ tesla. 4 + 6 + 5
10. a) In a one dimensional device the charge density is given by $\rho_v = \rho_0 \frac{x}{a}$. If $\vec{E} = 0$ at $x = 0$ & $v = 0$ at $x = a$, find v & \vec{E} .
- b) A homogeneous dielectric ($\epsilon_r = 2.5$) fills region 1 ($x < 0$) while region 2 ($x > 0$) is free space. If $\vec{D}_1 = 12 \vec{ax} - 10 \vec{ay} + 4 \vec{az}$ nc/m², find \vec{D}_2 & θ_2 .
- c) Derive continuity of current equation. 4 + 7 + 4
11. a) The magnetic field component of a plane wave in a lossless dielectric ($\mu_r = 1$) is $\vec{H} = 30 \sin (\lambda \pi \times 10^8 t - 5x) \vec{az}$ mA/m find
- ϵ_r
 - the wavelength and wave velocity
 - the wave impedance
 - the polarization of the wave
 - the corresponding electric field component.
- b) Develop the analogy between the uniform plane EM waves and the electric transmission line. 10 + 5



12. a) What are skin effect and skin depth ?

b) Show that in case of semi infinite solid conductor, the depth d is given by $\delta = \sqrt{\frac{2}{\omega \mu \sigma}}$ where ω , μ & σ have their

usual meaning.

c) What is polarization of electro-magnetic wave ?

d) Explain the significance of pointing vector. 4 + 4 + 4 + 3
