

**BACHELOR OF ENGINEERING (ELECTRICAL ENGINEERING)**  
**SECOND YEAR**  
**FIRST SEMESTER EXAM 2024**  
**FIELD THEORY**

Time:3 hours

Full Marks:100

(50 marks for each part)

Use separate Answer-script for each part

**PART-I**Answer any **three** questions. **Two marks** are for neatness. All symbols have their usual significance.

1. a) What is the fundamental definition of curl of a vector field? 8+8=16  
 Derive the expression for curl of a vector field  $\mathbf{M}$ , written as  $\nabla \times \mathbf{M}$  where,  $\nabla$  is the vector differential operator in Cartesian co-ordinates. What is the physical significance of Curl?  
 b) Establish the boundary relation for magnetic field when it passes through two different magnetic media having permeabilities  $\mu_1$  and  $\mu_2$ . Show one example for application of boundary relation for magnetic field.
2. a) What is Biot-Savart Law? 4+12=16  
 b) A thin conductor- ring, having rectangular loop sides of 4cm by 8cm, carries 50A in clockwise direction; find  $\mathbf{H}$  at a point on the axis positioned at a height of 10cm on the axis of the loop and also derive the formulae used if any using Biot-Savart Law.
3. 10+6=16  
 a) Establish  $\nabla \times \mathbf{H} = \mathbf{J} + \partial \mathbf{D} / \partial t$  and show the pictorial view of this relation. What is displacement current?  
 b) Derive  $\nabla \times \mathbf{E} = - \partial \mathbf{B} / \partial t$  and show the pictorial view of this relation.
4. a) Derive electromagnetic wave equations from Maxwell's equations.  
 b) Using electromagnetic wave equation in free space, obtain an analytical solution of the wave equation of Electric Field ( $\mathbf{E}$ ) considering it as a plane wave and also draw the wave propagation. 6+10=16
5. Write short notes on any four: 4×4=16  
 a)  $\nabla \cdot \mathbf{J} = 0$ ;    b)  $\nabla \cdot \mathbf{B} = 0$ ;    c) EM Plane wave velocity in free space;  
 d)  $\nabla \times \mathbf{H} = \mathbf{J}$ ; e) Stoke's Theorem and f) Poynting Vector.

[ Turn over

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**SUBJECT: FIELD THEORY**

Time: Three Hours

Full Marks: 100  
(50 Marks for each part)

**Use a separate Answer-Script for each part**  
Two marks are reserved for neat and well-organized answers

| Question No. | Part-II | Marks |
|--------------|---------|-------|
|--------------|---------|-------|

Answer any three questions

- |    |   |   |
|----|---|---|
| 1. | (a) Discuss about the relationship between electric potential and electric field intensity in differential form.  | 5 |
|    | (b) The potential in a space containing a dielectric medium of $\epsilon_{r1}$ is given by $\phi_1 = -7xy + 3yz - 4zx$ V, and another potential in a space containing a dielectric medium of $\epsilon_{r2}$ is given by $\phi_2 = -2x + 7y - 5yz$ V, where $x, y$ and $z$ are in meters. If the $y$ -component of electric flux density at the point (1,2,2)m is same for both the cases, then find the ratio of $\epsilon_{r1}$ and $\epsilon_{r2}$ . | 7 |
|    | (c) Prove that the electric flux line and equipotential are always normal to each other.  | 4 |
| 2. | (a) Justify or correct the following statement giving reasons: "Electric field intensity just off the conductor surface is half of the electric field intensity on the conductor surface".  | 7 |
|    | (b) Derive an expression for the mechanical pressure acting on a conductor surface.   | 3 |
|    | (c) Find an expression for the electric field intensity at the point located at a height "h" on the axis of a disc charge from the plane of the disc. The uniform charge density of the disc is $\rho_s$ C/m <sup>2</sup> and the permittivity of the medium is $\epsilon_r$ .  | 6 |
| 3. | (a) "Presence of void is degrading for insulation"-Justify or rectify the statement giving reasons.   | 8 |

- (b) A single-core lead sheathed cable has a core of 25cm diameter and two layers of different dielectric media of thickness 9cm each. The relative permittivities are 4.0 (inner dielectric) and 2.1 (outer dielectric). Calculate the maximum and minimum electric field intensities and their locations within the cable when the potential difference between the core and the sheath is 11kV. 8
4. (a) Derive the boundary condition between two different dielectric media with detailed discussion. 8
- (b) What do you mean by field utilization factor? Calculate the field utilization factor of a coaxial cylinder. 2+6
5. (a) Explain how the orthogonal properties between equipotential and electric field intensity is maintained in case of practical coaxial cable after converted through conformal transformation. 8
- (b) What is electric dipole? Determine the electric field intensity at a point developed due to the presence of an electric dipole. 1+7