Ref No.: Ex/EE/PC/B/T/226/2023

# B.E. ELECTRICAL ENGINEERING SECOND YEAR SECOND SEMESTER - 2023

## SUBJECT: FIELD THEORY

Time: Three Hours | Full Marks: 100 (50 Marks for each part)

**Use a separate Answer-Script for each part**

Two marks for neat and well-organized answers

| Question No. | | Part-I | Marks |
|---|---|---|---|

Answer any three questions

1. (a) A right isosceles triangle of side 1m has charges +1nC, +2nC and −1nC arranged on its vertices. Find the magnitude and direction of electric field intensity at the point P, which is the mid-point of the hypotenuse connecting the +1nC and -1nC charges. Medium is air. 7

   (b) A cylinder of unit volume is placed in a uniform field with its axis parallel to the direction of electric field. Determine the total charge enclosed by the unit cylinder. 6

   (c) Prove that the electric flux line and equipotential are always normal to each other. 3

2. (a) Derive the boundary condition for tangential component of electric field intensity on dielectric-dielectric interface. 6

   (b) Starting from the work done in assembling the charges causing the electric field, derive the expression for volume density of energy in an electric field. 7

   (c) Determine whether $\vec{E} = 3x\hat{i} + 4y\hat{j} - 5z\hat{k}$ is a valid form of electric field or not. 3

3. (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". 6

   (b) Derive an expression for the mechanical pressure acting on a conductor surface. 4

   (c) Justify or correct the following statement giving reasons: "Impregnation of porous solid dielectric should be done using a liquid dielectric whose relative permittivity is widely different from that of the solid dielectric". 6

[ Turn over

4. (a) In the case of a single core cable having three different dielectric media, explain under what condition the maximum electric field intensity will not occur just off the inner conductor surface. Derive the necessary expressions. 3+5

   (b) State and prove Uniqueness Theorem. Explain whether getting different solutions of Laplace's equation for a given problem by the use of different methods is violation of Uniqueness Theorem or not. 1+4+3

5. (a) Derive the expression of capacitance between two infinitely long transmission line conductors. 8

   (b) From the concept of electric dipole, derive the expressions for the components of electric field intensity at a given point above the earth surface due to a real point charge and its image charge. 8

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**SECOND SEMESTER EXAM 2023**

FIELD THEORY

Time:3 hours Full Marks:100

(50 marks for each part)

Use separate Answer-script for each part

PART-II

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

1. a) What is the **definition of curl?** Derive the **expression for curl** of a vector field **M** using **definition of curl**, written as $\nabla \times \mathbf{M}$ where $\nabla$ is the vector differential operator in Cartesian co-ordinates.

b) Establish **Boundary Conditions** for magnetic field when it passes through two different magnetic media having permeabilities $\mu_1$ and $\mu_2$ respectively. **8+8=16**

2. a) Establish the **Stoke's Theorem**.

b) Derive the **expression for Divergence of J and show $\nabla.\mathbf{J}=0$**

c) Establish $\nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ and show the pictorial view of this relation. **5+6+5=16**

3. a) Establish $\nabla \times \mathbf{H} = \mathbf{J}$ and explain its **physical significance**.

b) A square loop measuring 2 m by 2 m carries a 7.5 A steady current as shown in figure.1, where the loop is in the xz plane, the origin coinciding with a corner of the square. Using Biot-Savart law compute the B-field at a point on the y-axis 0.35 m from the origin in air material. **6+10=16**

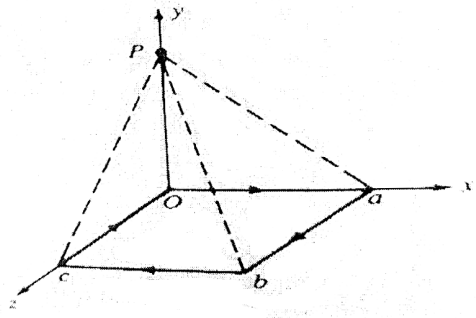


Fig.1

4. a) Derive Electromagnetic Wave equations using Maxwell's equations.

b) What is plane electromagnetic wave? Using electromagnetic wave equation of Magnetic Field ($\nabla^2 \mathbf{H} = \mu_0 \varepsilon_0 \partial^2 \mathbf{H}/\partial t^2$) in free space, obtain an **analytical solution of the wave equation** of Magnetic Field (H) considering it as a **plane wave** and also draw the wave propagation. **6+10=16**

**5. Write short notes on any two.**

a) $\nabla \times \mathbf{H} = \mathbf{J} + \partial \mathbf{D}/\partial t$ and the pictorial view of this relation.

b) Electromagnetic **wave polarizations**: Linear, Circular, Elliptical.

c) Poynting Theorem. **8+8=16**