Ref No.: Ex/EE/PC/B/T/226/2024

B.E. ELECTRICAL ENGINEERING SECOND YEAR SECOND SEMESTER - 2024

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-I	Marks

Answer any three questions

1. (a) A cylinder of unit volume is placed in a uniform field with its axis parallel to the direction of the electric field. Determine the total charge enclosed by the unit cylinder. 5

   (b) Consider a ring charge of radius 10cm and uniform charge density of +0.5nC/m and also a disc charge of radius 15cm and uniform charge density σ C/m^2. Both the charges are placed in the y-z plane with their centers at the origin. If the electric field intensity at a point of height 20cm lying on the x-axis is same due the ring and disc charges individually, then find the magnitude of σ. Relative permittivity of the medium is 3. 7

   (c) Consider that a unit positive charge is moved from point 1 to point 2 by a small distance dl in an electric field. Then why the negative sign is incorporated in the following equation for the potential difference: $\phi_2 - \phi_1 = -\vec{E}.\vec{dl}$ 4

2. (a) Correct or justify the following statement with reasons: "The divergence of a vector field at any location is the total flux of that vector field coming out per unit volume at that given location". 6

   (b) Derive an expression for the divergence of a vector in cylindrical coordinate system. 7

   (c) A uniform electric field is parallel to the z-axis. In which direction can a unit positive charge be displaced in this field without any external work being done on the charge? 3

3. (a) Correct or justify the following statement with reasons: "Electric field intensity just off the conductor surface is half of the electric field intensity exactly on the conductor surface". 6

[Turn over

(b) Correct or justify the following statement with reasons: "On any conductor-dielectric boundary, if the normal components of electric field intensity is E_n and the surface charge density is σ, then $E_n = \sigma$". 6

(c) Prove that the equation $D_{2n} - D_{1n} = \rho_s$ is valid for dielectric-dielectric boundary as well as for conductor-dielectric boundary. 4

4. (a) Discuss with the help of diagram an orthogonal coordinate system in which out of the three constant coordinate surfaces one is a constant distance surface, while the other two are constant angle surfaces. 6

(b) Derive the FDM equations for the unknown node potentials in 2-D system with equal nodal distances in homogeneous medium. 5

(c) Correct or justify the following statement with reasons: "The relative permittivity of the liquid dielectric used for impregnation must be much higher compared to the relative permittivity of the solid insulation being impregnated". 5

5. (a) Prove that the equipotentials due to an infinitely long line charge and its image wrt an infinitely long conducting plane are cylinders with axes parallel to the two line charges. 7

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

(c) In the case of a single core single dielectric cable, for a given value of the radius of outer sheath (R), determine the value of electric field intensity on the inner conductor of radius r for most economical use of dielectric medium. 5

Ref. No.: Ex/EE/PC/B/T/226/2024

B.E. ELECTRICAL ENGINEERING
SECOND YEAR
SECOND SEMESTER EXAM 2024

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 **C,** using **definition of curl,** written as $\nabla \times \mathbf{C}$ where $\nabla$the vector differential operator in Cartesian co-ordinates and explain its **physical significance.**

b) Derive the$\nabla.\mathbf{B}$ **from definition of Divergence in any** co-ordinates and show that $\nabla.\mathbf{B} = 0$ **where B is magnetic flux density.** **8+8=16**

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

b) Establish $\nabla \times \mathbf{H} = \mathbf{J}$.

c) Establish $\nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ and show the pictorial view of this relation. **6+4+6=16**

3. a) Establish **Boundary Conditions** for magnetic field when it passes through two different magnetic media having permeabilities μ_1 and μ_2 respectively& Show one example for application of this relation.

b) Derive electromagnetic wave equation of Magnetic Field ($\nabla^2\mathbf{H} = \mu_0\varepsilon_0\, \partial^2 \mathbf{H}/\partial t^2$) in free space; then obtain an analytical solution of the wave equation of Magnetic Field (H) considering it as a **plane wave** and also draw the wave propagation. **7+9=16**

4. a) Establish "Poynting Theorem".

b) A square loop measuring 1.5 m by 1.5 m carries a 7.5A steady current, where the loop is in the xz plane, using Biot-Savart law compute the B-field and Energy density at a point 0.35 m away **on axis of the loop**(the y-axis) in air material. Derive the formulae used if any. **7+9=16**

5. 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) What do you understand by electromagnetic wave polarization? Explain. Also calculate the speed of any electromagnetic wave in **free space.** **8+8=16**