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CBCS SCHEME

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21EC54

Fifth Semester B.E./B.Tech. Degree Examination, June/July 2026
Electromagnetic Waves

Time: 3 hrs. Max. Marks: 100

Note: ***Answer any FIVE full questions, choosing ONE full question from each module.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. State and explain Coulomb's law in vector form. **(06 Marks)**

b. Two point charges 20 nC and -20 nC are situated at (1, 0, 0) and (0, 1, 0) in free space. Determine Electric field intensity at (0, 0, 1). **(08 Marks)**

c. Define Electric field intensity and Electric flux density. Also establish relationship between two. **(06 Marks)**

OR

2 a. A uniform charge of infinite length , ρ_L = 20 nC/m lies along Z – axis. Find Electric field intensity at point P(6, 8, 3) in air. **(05 Marks)**

b. Calculate the total charge within the universe if volume charge distribution $\rho_V = \frac{e^{-2r}}{r^2}$ c/m^3. **(08 Marks)**

c. Given Electric flux density $\vec{D} = 0.3r^2\ \vec{a}_r$ nC/m^2 :

i) Find Electric field intensity, $\vec{E}$ at P(r = 2m , $\theta = 25°$, $\phi = 90°$)
ii) Find charge Q, within the sphere r = 3.
iii) Find total electric flux leaving the sphere r = 4. **(07 Marks)**

Module-2

3 a. Using Gauss law, derive an expression for Electric field intensity at a distant point due to infinite line charge. **(08 Marks)**

b. Derive an expression for continuity of current. **(06 Marks)**

c. Calculate numerical values for electric scalar potential 'V' and volume charge density ρ_V at a point P(1, 2, 3) in free space if $V = \frac{4YZ}{X^2+1}$. **(06 Marks)**

OR

4 a. Define Electric Scalar Potential. Derive an expression for potential due to point charge. **(05 Marks)**

b. Given the flux density $\vec{D} = \frac{16}{r} \cos 2\theta\ \vec{R}_0$ C/m^2. Use two different methods to find total charge within the region $1 < r < 2$ m , $1 < \theta < 2$ rad , $1 < \phi < 2$ rad. **(08 Marks)**

c. Obtain an expression for the energy expanded in moving a point charge in an electric field. **(07 Marks)**

Module-3

5 a. Derive Poisson's and Laplace's equation. **(06 Marks)**

b. Evaluate both sides of Stoke's theorem for the field $H = 10 \sin\theta \vec{a}_\theta$ and the surface $r = 3$, $0 \le \theta \le 90°$, $0 \le \phi \le 90°$. Let the surface has $\vec{a}_r$ direction. **(08 Marks)**

c. State and explain Biot – Savart's law. **(06 Marks)**

OR

6 a. State and prove Uniqueness Theorem. **(06 Marks)**

b. Using Laplace equation, determine capacitance of parallel plate capacitor. **(08 Marks)**

c. State and explain Ampere's law. **(06 Marks)**

Module-4

7 a. A point charge of $Q = -1.2C$ has velocity $v = (5\vec{a}_x + 2\vec{a}_y - 3\vec{a}_z)$ m/s. Find the force exerted on the charge if

i) $\vec{E} = -18\vec{a}_x + 5\vec{a}_y - 10\vec{a}_z$ V/m ii) $\vec{B} = -4\vec{a}_x + 4\vec{a}_y + 3\vec{a}_z$ T **(06 Marks)**

b. Discuss Magnetic boundary conditions at the interface between two different magnetic materials. **(08 Marks)**

c. Obtain an expression for the force between differential current elements. **(06 Marks)**

OR

8 a. Given a ferrite material which we shall specify to be operating in a linear mode with $\vec{B} = 0.05$ T. Let us assume $\mu_r = 50$. Calculate

i) χ_m magnetic susceptibility.
ii) M magnetization
iii) H magnetic field intensity. **(06 Marks)**

b. Define inductance and derive an expression for inductance of toroidal coil of 'N' turns and a current 'I'. **(06 Marks)**

c. State and explain Faraday's law of Electromagnetic induction. **(08 Marks)**

Module-5

9 a. List Maxwell's equation in point and integral form. **(08 Marks)**

b. What is Displacement Current? Derive Maxwell's equation in point form, from Ampere's law. **(06 Marks)**

c. Discuss wave propagation in good conductors. **(06 Marks)**

OR

10 a. Obtain solution for the wave equation for uniform plane wave. **(08 Marks)**

b. Define Skin effect or depth of penetration. **(04 Marks)**

c. State and prove Poynting Theorem. **(08 Marks)**

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