CBCS SCHEME

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21EC54

Fifth Semester B.E./B.Tech. Degree Examination, June/July 2025
Electromagnetic Waves

Time: 3 hrs. Max. Marks: 100

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

Module-1

1 a. What do you mean by scalar and vector fields? Show the difference between two. **(06 Marks)**

b. Given three points in Cartesian coordinate system as A(3, -2, 1), B(-3, -3, 5), C(2, 6, -4).
Find : i) The vector from A to C
ii) The unit vector from B to A
iii) The distance from B to C
iv) The vector from A to the midpoint of the straight line joining B to C. **(08 Marks)**

c. State Coulomb's law of force between any two point charges and also in vector form. **(06 Marks)**

OR

2 a. A charge $Q_2 = 12$ inc is located in free space at P_2 (-0.03, 0.01, 0.04)m. Find the force on Q_2 due to Q_1 where $Q_1 = 110\mu C$ at P_1(0.03, 0.08, -0.02)m. **(06 Marks)**

b. A volume charge density is expressed as $\rho_v = 10z^2 x \sin \pi y$. Find the total charge inside the volume $(-1 \leq x \leq 2)$, $(0 \leq y \leq 1)$, $(3 \leq z \leq 3.6)$. **(06 Marks)**

c. Derive the expression for electric field intensity due to infinite line charge. **(08 Marks)**

Module-2

3 a. State and prove the Gauss's law. **(06 Marks)**

b. Consider a coaxial cable with inner radius 'a' and outer radius 'b'. Derive the expression for flux density ($\overline{D}$) for the region $a < r < b$ using Gauss's law. **(08 Marks)**

c. The flux density $\overline{D} = r/3\ \overline{a}_r\ nc/m^2$ is in the free space :
i) Fine $\overline{E}$ at r = 0.2m
ii) Find the electric flux leaving the sphere of r = 0.2m.
iii) Find the total charge within the sphere of r = 03.m. **(06 Marks)**

OR

4 a. Derive Maxwell first equation as applied to the electro statics, using Gauss's law. State the divergence theorem using Maxwell's first equation. **(06 Marks)**

b. Evaluate the both sides of divergence theorem for the field $\overline{D} = 2xy\ \overline{a}_x + x^2\ \overline{a}_y\ c/m^2$ and rectangular parallel piped formed by the planes x = 0 and x = 1, y = 0 and y = 2 and z = 0 and z = 3. **(08 Marks)**

c. Derive the expression for the work done in moving a point charge in an electric field. **(06 Marks)**

Module-3

5 a. Determine whether or not the following potential fields satisfy the Laplace's equation :
i) $V = x^2 - y^2 + z^2$ ii) $V = r\cos\phi + z$ iii) $V = r\cos + \theta + \phi$. **(06 Marks)**

b. Using the Laplace's equation, derive an expression for capacitance per unit length of a coaxial cable using the following boundary conditions. $V = V_0$ at $r = a$ and $V = 0$ at $r = b$, $b > a$. **(08 Marks)**

c. State and explain Biot – Savart law applicable to magnetic field. **(06 Marks)**

OR

6 a. Derive the expression for a curl , applying Ampere's circuital law to an incremental surface element. **(08 Marks)**

b. State and prove the Stoke's theorem. **(06 Marks)**

c. What is scalar magnetic potential? Explain Laplace equations for scalar magnetic potential. **(06 Marks)**

Module-4

7 a. Define and explain the terms magnetic flux and magnetic flux density. Obtain the magnetic flux using magnetic flux density in coaxial cable. **(08 Marks)**

b. In certain region, the magnetic flux density in a magnetic material with $\chi_m = 6$ is given and $\bar{B} = 0.005y^2\,\bar{a}_x$ T. At $y = 0.4$m , find the magnitude of : i) $\bar{J}$ ii) $\bar{J}_b$ iii) $\bar{J}_T$. **(06 Marks)**

c. Discuss the boundary conditions for magnetic field based on the normal component of the $\bar{B}$ and $\bar{H}$. **(06 Marks)**

OR

8 a. Derive an expression for the magnetic force between differential current elements. **(06 Marks)**

b. A conductor of length 2.5m in $z = 0$ and $x = 0$ carries a current of 12A in $-\bar{a}_y$ direction. Calculate the uniform flux in the region , if the force on the conductor is 12×10^{-2} N in the direction specified by $\left[\frac{-\bar{a}_x + \bar{a}_z}{\sqrt{2}}\right]$. **(08 Marks)**

c. State and explain Faraday's law of electromagnetic induction in integral and point form. **(06 Marks)**

Module-5

9 a. Write the Maxwell's equations in the integral form and explain the physical significance. **(06 Marks)**

b. Two parallel conducting plates of area 0.05m^2 are separated by 2mm of lossy, dielectric for which $\varepsilon_r = 8.3$ and $\sigma = 8 \times 10^{-4}$ S/m. given an applied voltage $V = 10\sin 10^7 t$ V. Find total r.m.s current. **(08 Marks)**

c. Do the fields $\bar{E} = E_m \sin x \sin t\, \bar{a}_y$ and $\bar{H} = \frac{E_m}{\mu o} \cos x \cos t\, \bar{a}_z$ satisfy the Maxwell's equations. **(06 Marks)**

OR

10 a. Write short notes on Retarded potential. **(06 Marks)**

b. Given $E = E_o z^2 e^{-t}\, \bar{a}_x$ in free space, determine if there exist a magnetic field such that both Faraday's law and Ampere's circuital law are satisfied simultaneously. **(08 Marks)**

c. Discuss the propagation of uniform plane wave in good conductor. **(06 Marks)**

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