CBCS SCHEME

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17EE45

Fourth Semester B.E. Degree Examination, Aug./Sept.2020

Electromagnetic Field Theory

Time: 3 hrs. Max. Marks: 100

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

Module-1

1 a. Given two vectors, $\vec{A} = \vec{a}_x + \vec{a}_y - 3\vec{a}_z$, $\vec{B} = 3\vec{a}_x - 2\vec{a}_y - 2\vec{a}_z$, find (i) $|2\vec{A} - \vec{B}|$ (ii) $|\vec{A}|(\vec{A} + \vec{B})$ (iii) Unit vector along $(2\vec{A} - \vec{B})$ **(08 Marks)**

b. Find the cross product of the two vectors $\vec{A} = 2\vec{a}_x - \vec{a}_y + 3\vec{a}_z$ and $\vec{B} = -5\vec{a}_x - 6\vec{a}_y + 7\vec{a}_z$ and then find the unit vector normal to $\vec{A}$ and $\vec{B}$. Also find the angle between $\vec{A}$ and $\vec{B}$. **(06 Marks)**

c. State Gauss's law. Determine the expression for electric field intensity at a distance 'r' from an infinite line charge using Gauss's law. **(06 Marks)**

OR

2 a. State and explain Coulomb's law in vector form. **(08 Marks)**

b. Given two points P(–3, 2, 1) and Q(r = 5, θ = 20°, ϕ = –70°), find:
(i) Spherical coordinates of P
(ii) Rectangular coordinates of Q
(iii) Distance from P to Q **(06 Marks)**

c. Determine:
(i) Gradient of the scalar field $u = \rho^2 z \cos 2\phi$
(ii) Divergence of the vector $\vec{A} = x^2 yz\vec{a}_x + xz\vec{a}_z$. **(06 Marks)**

Module-2

3 a. Find the energy stored in free space for the region $2\times10^{-3}\text{m} < r < 3\times10^{-3}\text{m}$, $0 < \theta < \frac{\pi}{2}$, $0 < \phi < \frac{\pi}{2}$ given the potential field V = 100/r Volts. **(08 Marks)**

b. Two point charges of –1nC and +1nC are located at A(–3, 1, 5) and B(6, –5, 2)m respectively. Find the electric potential at point P(3, –6, –9)m. **(06 Marks)**

c. Derive the boundary conditions between two dielectric materials. **(06 Marks)**

OR

4 a. Given $\vec{E}_1 = 2\vec{a}_x - 3\vec{a}_y + 5\vec{a}_z$ V/m at the charge free interface shown in Fig.Q4(a), find $\vec{D}_2$ and angles ϕ_1 and ϕ_2.

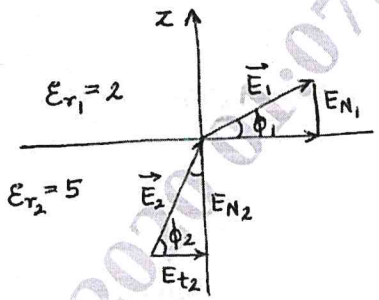

Fig.Q4(a) **(08 Marks)**

b. Derive an expression for the potential of a coaxial cable in the dielectric space between inner and outer conductors. **(06 Marks)**

c. Derive an expression for capacitance of a parallel plate capacitor with a dielectric interface parallel to the plates. **(06 Marks)**

Module-3

5 a. In spherical coordinates, V = 0 at r = 0.1 m and V = 100 V at r = 2m. Assuming free space between the concentric spherical shell, find $\vec{E}$ and $\vec{D}$. **(08 Marks)**

b. Write Laplace and Poisson's equations in all three coordinate systems. **(06 Marks)**

c. In cylindrical coordinate system, $\vec{H} = (4r - 2r^2)\vec{a}_\phi$ A/m, $0 \le r \le 1$. Find:

(i) $\vec{J}$ as a function of r within the cylinder, (ii) Total current that passes through the surface, z = 0 and $0 \le r \le 1$ m in $\vec{a}_z$ direction. **(06 Marks)**

OR

6 a. Find the potential and volume charge density at P(0.5, 1.5, 1)m in free space given the potential field as under, $V = 3x^2 - y^2 - z^2$ Volts. **(08 Marks)**

b. State and explain Biot-Savart's law. **(06 Marks)**

c. If $\vec{H} = 20\rho^2\vec{a}_\phi$ A/m, determine current density $\vec{J}$. **(06 Marks)**

Module-4

7 a. Derive boundary conditions at the boundary between two magnetic materials of different permeabilities. **(08 Marks)**

b. A point charge of Q = –20 μc is moving with a velocity of $\vec{V} = (-3\vec{a}_x - 4\vec{a}_y + 4.5\vec{a}_z) \times 10^6$ m/s. Find the magnitude of the vector force exerted on the moving particle by the field.

(i) $\vec{E} = \vec{a}_x + 1.5\vec{a}_y - 2\vec{a}_z$ kV/m (ii) $\vec{B} = 4\vec{a}_x - 6\vec{a}_y + 10\vec{a}_z$ mT. **(06 Marks)**

c. Obtain the relation between current density $\vec{J}$ and volume charge density ρ_v. **(06 Marks)**

OR

8 a. The z = 0 plane marks the boundary between two magnetic media. Medium-1 is the region z > 0 and medium 2 is the region z < 0. The magnetic flux density in medium-1 is $\vec{B}_1 = 1.5\vec{a}_x + 0.8\vec{a}_y + 0.6\vec{a}_z$ mT. Find the magnetic flux density of medium-2. Assume medium-1 as free space and relative permeability of medium-2 as 100. **(08 Marks)**

b. Derive the expression for self inductance of a coaxial cable. **(06 Marks)**

c. Calculate the inductance of 10m long coaxial cable filled with material for which $\varepsilon_r = 18$, $\sigma = 0$, $\mu_r = 80$. The external and internal diameters of the cable are 1 mm and 4 mm respectively. **(06 Marks)**

Module-5

9 a. Explain skin effect and skin depth. Derive the expression for skin depth. **(08 Marks)**

b. List Maxwell's equations for time-varying fields in point form and integral form. **(06 Marks)**

c. Starting from Ampere's circuital law, derive an expression for displacement current density for time varying fields. **(06 Marks)**

OR

10 a. A uniform plane wave with 10 mHz frequency has average Poynting vector of 1 W/m^2. If the medium is a perfect dielectric with $\mu_r = 2$, $\varepsilon_r = 3$, find:
(i) velocity (ii) wavelength (iii) intrinsic impedance. **(08 Marks)**

b. A short vertical transmitting antenna erected on the surface of a conducting earth produces $E_{effective} = 150 \sin \theta$ V/m at points at a distance of 2 kms from the antenna. Compute the Poynting vector. **(06 Marks)**

c. A 10 giga Hz uniform plane wave travelling in free space in x-direction has $E_z = 1$ V/m. Find the value of magnetic field and propagation constant. **(06 Marks)**

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