CBCS SCHEME

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17EE45

Fourth Semester B.E. Degree Examination, Feb./Mar. 2022
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. Define scalar and vector for given vector $\vec{A} = 2\hat{a}_x - \hat{a}_y + 2\hat{a}_z$; $\vec{B} = 2\hat{a}_x - 3\hat{a}_y + 2\hat{a}_z$. Determine : i) Angle between $\vec{A}$ and $\vec{B}$ ii) Unit vector perpendicular to both $\vec{A}$ and $\vec{B}$. **(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. **(06 Marks)**

c. Find the following : i) Gradient of the scalar field $u = P^2Z\cos 2\phi$

ii) Divergence of the vector $\vec{A} = x^2yz\hat{a}_x + xz\hat{a}_z$. **(06 Marks)**

OR

2 a. State Gauss Law. Obtain Gauss law in point form. **(06 Marks)**

b. Two uniform line charges of density 4n c/m and 6n c/m lie in x = 0 plane at y = + 5m and y = –6m respectively find $\vec{E}$ at (4, 0, 5)m. **(06 Marks)**

c. Evaluate both sides of gauss – divergence theorem for the field $\vec{D} = 2xyz\hat{a}_x + 3y^2z\hat{a}_y + x\hat{a}_z\, c/m^2$ the region is defined by $-1 \le x, y, z \le 1$m. **(08 Marks)**

Module-2

3 a. Find an expression establishing the relationship between electric field intensity and gradient of potential. **(05 Marks)**

b. With usual notation derive boundary conditions at boundary between a dielectric and conductor in an electric field. **(08 Marks)**

c. Determine the work done in carrying a charge of –2C from (2, 1,–1) to (8, 2, –1) in the electric field $\vec{E} = y\hat{a}_x - x\hat{a}_y\ V/m$ considering the path along the parabola $x = 2y^2$. **(07 Marks)**

OR

4 a. With usual notation prove that $\nabla \cdot J = \frac{\partial \rho_v}{\partial t}$. **(06 Marks)**

b. Determine the capacitance at a capacitor consisting of two parallel Plate's 30cm × 30cm surface area separated by 5mm in air. What is total energy stored by capacitor when capacitor is charged to a potential of 500V? What is the energy density? **(06 Marks)**

c. Potential is given by $V = 2(x + 1)^2(y + 2)^2(z + 3)^2$ volt in free space. At a point P(2, –1, 4) calculate : i) Potential ii) Electric field intensity iii) Flux density iv) Volume charge density. **(08 Marks)**

Module-3

5 a. Starting from point form of Gauss law derive Laplace equation and Poisson's equations. Also state and derive uniqueness theorem. **(10 Marks)**

b. State and explain Biot – Savart law. **(05 Marks)**

c. If the field of a region in space is given by $\vec{E} = 5\cos z\hat{a}_z\ V/m$, check whether it represents possible electric field. **(05 Marks)**

OR

6 a. Discuss the concept of vector magnetic potential and hence show that $\vec{A} = \frac{\mu_0}{4\pi}\int \frac{\vec{J}}{r} dv$. **(06 Marks)**

b. State and prove that Stroke's theorem. **(06 Marks)**

c. If the vector magnetic potential at a point in a space is given as $\vec{A} = 100r^{1.5}\hat{a}_z$ Wb/m. Find the following : i) $\vec{H}$ ii) $\vec{J}$ iii) determine the total current that crosses the surface r = 1m, $0 < \phi < 2\pi$ and z = 0. **(08 Marks)**

Module-4

7 a. Derive an equation for the force between the two differential current elements. **(06 Marks)**

b. Derive the expression for the inductance of a Toroid. **(06 Marks)**

c. A point charge Q = 18nC has a velocity of 5×10^6m/s in the direction $\hat{a}_v = 0.6\hat{a}_x + 0.75\hat{a}_y + 0.3\hat{a}_z$. Calculate the magnitude of the force exerted on the charge by field :

i) $\vec{E} = -3\hat{a}_x + 4\hat{a}_y + 6\hat{a}_z$ K V/m

ii) $\vec{B} = -3\hat{a}_x + 4\hat{a}_y + 6\hat{a}_z$ K mT

iii) $\vec{B}$ and $\vec{E}$ acting together. **(08 Marks)**

OR

8 a. Derive the magnetic boundary conditional at the interface between two different magnetic material. **(10 Marks)**

b. Calculate the inductance of a solenoid of 400 turns wound on a cylindrical tube of 10cm diameter and 50cm length. Assume that solenoid is in air. **(05 Marks)**

c. A current element 4cm long is along y axis with a current 10mA flowing in y – direction. Detemrne the force on the current element due to the magnetic field, if the magnetic field $\vec{H} = \frac{5}{\mu}\hat{a}_x$ A/m. **(05 Marks)**

Module-5

9 a. Starting from the concept of Faraday's law of electromagnetic induction, derive the Maxwell's equation $\nabla \times \vec{E} = \frac{-\partial \vec{B}}{\partial t}$. **(08 Marks)**

b. List the Maxwell's equations in point form and integral form. **(06 Marks)**

c. If the electric field intensity in free space is given by $\vec{E} = E_m \sin\alpha_x \sin(\omega t - \beta z)\hat{a}_y$ V/m. Find an expression for the magnetic field intensity $\vec{H}$. **(06 Marks)**

OR

10 a. State and prove Poynting's theorem. **(08 Marks)**

b. A 160MHz plane wave penetrates through aluminium of conductivity 10^5 ʊ/m $\epsilon_r = \mu_r = 1$. Calculate the skin depth and also depth at which wave amplitude decreases to 13.5% of its initial value. **(06 Marks)**

c. The magnetic field intensity of uniform plane wave in air is 20 A/m in $\hat{a}_y$ direction. The wave is propagating in the $\hat{a}_z$ direction at an angular frequency at 2×10^9rad/sec.
Find : i) phase shift constant ii) wavelength iii) frequency iv) Amplitude of electric field intensity. **(06 Marks)**