CBCS SCHEME

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17EE45

Fourth Semester B.E. Degree Examination, Dec.2019/Jan.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 the two co-planar vectors $\bar{A} = 3\bar{a}_x + 4\bar{a}_y - 5\bar{a}_z$ and $\bar{B} = -6\bar{a}_x + 2\bar{a}_y + 4\bar{a}_z$, obtain:

(i) Cross product of $\bar{A}$ and $\bar{B}$

(ii) Unit vector normal to the plane containing the vectors $\bar{A}$ and $\bar{B}$ **(08 Marks)**

b. Write down the relationships between the Cartesian and spherical system. **(06 Marks)**

c. Derive the relation between electric fluid ($\bar{E}$) intensity and electric flux density ($\bar{D}$). **(06 Marks)**

OR

2 a. Derive an expression for the electric field intensity ($\bar{E}$) due to infinite line charge. **(10 Marks)**

b. Find the electric field intensity ($\bar{E}$) at origin if the following charge distributions are present in free space.

(i) Point charge 12 ηc at P(2, 0, 6)

(ii) Uniform line charge of line charge density 3 ηc/m at x = 2, y = 3

(iii) Uniform surface charge of density 0.2 ηc/m^2 at x = 2. **(10 Marks)**

Module-2

3 a. An electric potential is given by $V = \frac{60\sin\theta}{r^2}$ v, find V and $\bar{E}$ at P(3, 60°, 25°). **(08 Marks)**

b. Derive the expression for potential difference due to infinite line of charge. **(06 Marks)**

c. Determine work done in carrying a charge of –2C from (2, 1, –1) to (8, 2, –1) in the electric field $\bar{E} = y\bar{a}_x + x\bar{a}_y$ V/m in Cartesian coordinates considering the path along the parabola $x = 2y^2$. **(06 Marks)**

OR

4 a. Obtain the boundary conditions between two perfect dielectric materials. **(08 Marks)**

b. The electric field intensity in polystyrene ($\epsilon_r = 2.55$) filling the space between the plates of a parallel plate capacitor is 10 KV/m. The distance between the plates is 1.5 mm. Calculate:

(i) The surface charge density of free charge on the plates.

(ii) The potential difference between the plates. **(06 Marks)**

c. State the properties of conductor. **(06 Marks)**

Module-3

5 a. State and explain Uniqueness theorem. **(06 Marks)**

b. Conducting spherical shells with radii a = 10 cm and b = 30 cm are maintained at a potential difference of 100 V such that V(r = b) = 0 and V(r = a) = 100 V. Determine V and E in the region between the shells of $\epsilon_r = 2.5$ in the region, determine the total charge induced on the shells. **(10 Marks)**

c. Determine whether or not the following potential fields satisfy the Laplace's equation $V = r\cos\phi + z$. **(04 Marks)**

OR

6 a. State and prove Ampere's circuital law. **(08 Marks)**

b. If a particular field is given by, $\bar{F} = (x + 2y + az)\bar{a}_x + (bx - 3y - z)\bar{a}_y + (4x + cy + 2z)\bar{a}_z$ then find the constants a, b and c such that the field is irrotational. **(04 Marks)**

c. Given $\bar{H} = 20r^2\bar{a}_\phi$ A/m,

(i) Determine the current density $\bar{J}$.

(ii) Also determine the total current that crosses the surface r – 1 m, $0 \le \phi < 2\pi$ and z = 0 (in cylindrical coordinates). **(08 Marks)**

Module-4

7 a. Derive the expression for the force on a differential current element placed in a magnetic field. **(06 Marks)**

b. Find the force per meter length between two long parallel wires separated by 10 cm in air and carrying a current of 10 A in the same direction. **(06 Marks)**

c. A solenoid with $N_1 = 1000$, $\ell_1 = 50$ cm and $r_1 = 1$ cm is concentric within a second coil of $N_2 = 2000$, $r_2 = 2$ cm and $\ell_2 = 50$ cm. Find the mutual inductance assuming free-space conditions. **(08 Marks)**

OR

8 a. With a neat sketch, obtain the expression for inductance of toroid. **(08 Marks)**

b. Calculate the inductance of a solenoid of 200 turns wound tightly on a cylindrical tube of length 60 cm and of diameter 6 cm, given that medium is air. Derive the expression used. **(08 Marks)**

c. Define: (i) Magnetization (ii) Permeability **(04 Marks)**

Module-5

9 a. Given $\bar{E} = E_m \sin(\omega t - \beta z)\bar{a}_y$ in free space, find $\bar{D}$, $\bar{B}$ and $\bar{H}$. **(08 Marks)**

b. Obtain the solution of wave equation for uniform plane wave in free space. **(08 Marks)**

c. The depth of penetration in a certain conducting medium is 0.1 m and the frequency of the electromagnetic wave is 1 MHz. find the conductivity of the conducting medium. **(04 Marks)**

OR

10 a. Derive the expression for integral form and point form of Faraday's law. **(07 Marks)**

b. Wet marshy soil is characterized by $\sigma = 10^{-2}$ s/m, $\epsilon_r = 15$ and $\mu_r = 1$. At frequencies 60 Hz, 1 MHz, 100 MHz and 10 GHz, indicate whether soil be considered as conductor or dielectric. **(08 Marks)**

c. Write a short note on skin effect in conductors. **(05 Marks)**

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