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18EC55

# Fifth Semester B.E. Degree Examination, June/July 2024
## 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. State and derive Coulomb's law. **(06 Marks)**

b. Find the force on charge $Q_1$ located at (4, -2, 1) m due to charge $Q_2$ located at (3, -1, -2) m. $Q_1 = 200\ \mu C$, $Q_2 = 300\ \mu C$. **(07 Marks)**

c. Calculate the electric field intensity E at (-1, 3, -2) m due to infinite line charges with $\rho_l = 25\ nC/m$ lying along x-axis and $\rho_l = 50\ nC/m$ lying along y-axis. **(07 Marks)**

**OR**

2 a. Derive electric field intensity E due to infinite line charge. **(06 Marks)**

b. Two point charges $Q_1 = 5\ \mu C$ and $Q_2 = -3\ \mu C$ are located in free space at (1, 0, -2) m and (-2, 1, 3) m respectively. Find electric field intensity E at P(-3, 2, -1) m. **(07 Marks)**

c. Calculate the electric field intensity E at (-2, 1, -3) m due to infinite sheet charges :

$\rho_S = \frac{1}{6\pi} nC/m^2$ located at y = 3 m and

$\rho_S = \frac{1}{3\pi} nC/m^2$ located at z = -5 m **(07 Marks)**

### Module-2

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

b. Given $D = \frac{5r^3}{y} a_r C/m^2$ in cylindrical co-ordinates. Prove divergence theorem for the volume enclosed by r = 2m, r = 3 m, z = 0 and z = 5 m. **(07 Marks)**

c. Find the total charge in a volume defined by six planes for which, $2 \le x \le 3$, $3 \le y \le 4$, $4 \le z \le 5$, if $D = 5x^2 a_x + 4y^2 a_y + 3z a_z\ C/m^2$. **(07 Marks)**

**OR**

4 a. Using Gauss's law, derive the expressions for $\overline{D}$ and $\overline{E}$ due to co-axial cylindrical conductors. **(06 Marks)**

b. Calculate the total electric flux density due to two uniform line charges of 30 μC/m lying along x-axis and 50 μC/m lying along z-axis, at (2, 3, 4)m. **(07 Marks)**

c. In an electric field, potential field is $V = 5x^2 + 3y^3 + 8z$ volts. Find

(i) $\overline{E}$ (ii) $|E|$ (iii) $\overline{D}$ at (-3, 2, 4) m **(07 Marks)**

### Module-3

5 a. Using Laplace's equation, derive the expression for potential (V) and electric field strength E due to two concentric cylinders of infinite length. **(06 Marks)**

b. In spherical co-ordinates V = 750 volts at r = 25 cm and E = 825 $a_r$ V/m at r = 75 cm. Determine the location of voltage reference if potential depends only on r. **(07 Marks)**

c. State and prove Ampere's circuital law. **(07 Marks)**

**OR**

6 a. Using Biot-Savart's law, derive the expression for magnetic field intensity "H" due to infinite long conductor. **(06 Marks)**

b. In spherical co-ordinates, V = 0 for r = 0.2 m and V = 200 volts for r = 3 m. Assuming free space between concentric spheres (Shells) find electric field intensity E and flux density D. **(07 Marks)**

c. Find magnetic field intensity H at the center of a square loop of sides equal to 10 m and carrying a current of 5 amp. **(07 Marks)**

## Module-4

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

b. Calculate the force on a straight conductor of length 0.5 m carrying a current of 10 amp in the z-direction, where $\overline{B} = 5\times10^{-3}a_x$ Tesla and $B = 6\times10^{-3}a_y$ Tesla. **(07 Marks)**

c. A solenoid with air core has 2000 turns and a length of 700 mm. Core radius is 50 mm. Find self inductance. **(07 Marks)**

**OR**

8 a. Derive the equation for force between two parallel current carrying conductors. **(06 Marks)**

b. Derive tangential and normal boundary conditions (magnetic) between two media of permeabilities $\mu_1$ and $\mu_2$. **(07 Marks)**

c. Find the inductance per unit length of a co-axial conductor with an inner radius of a = 4 mm and outer radius of b = 10 mm. Assume $\mu_r = 1$. **(07 Marks)**

## Module-5

9 a. State the inconsistency of Ampere's law, for time varying fields. Derive Maxwell's equation to correct it. **(06 Marks)**

b. Derive general plane wave equation in terms of E, taking help of the Maxwell's equation (for free space). **(07 Marks)**

c. A plane wave travelling in positive z-direction in a lossless unbounded medium has permeability 5 times that of free space and a dielectric constant 3 times that of free space.

(i) Find phase velocity of the wave

(ii) If E has only x-component with amplitude 25 V/m, find amplitude and direction of H. **(07 Marks)**



**OR**

10 a. Prove that conduction current and displacement current are equal. **(06 Marks)**

b. State and explain Poynting theorem. **(05 Marks)**

c. Determine following parameters for a medium with $\epsilon_r = 4$, $\mu_r = 1$, $\sigma = 20\times10^{-2}$ S/m, f = 1 mHz.

(i) Attenuation constant
(ii) Phase shift constant
(iii) Propagation constant
(iv) Wavelength
(v) Phase velocity
(vi) Intrinsic impedance
(vii) Skin depth ($\delta$) **(09 Marks)**

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