

UNIT- III ELECTRIC AND MAGNETIC FIELDS IN MATERIALS

Laplace's and Poisson Equations

1. Given the potential field, $V = \frac{50 \sin \theta}{r^2} V$ in free space, determine whether 'V' satisfies Laplace's equation.
2. If a potential V is 2 volts at x=1mm, and is zero at x=0 and volume charge density, $\rho_v = -10^6 \epsilon_0 C/m^3$, constant throughout the free space region between x=0 and x=1mm, calculate V at x=0.5mm and E_x at x=1.

Energy and Energy Density

3. A coil has a self-inductance of 1 Henry and a resistance of 4 ohms. If it is connected to a 40 volt DC supply, estimate the energy stored in the magnetic field when the current has attained its final steady value.
4. If $C_1=100mF$ and $C_2=50mF$, calculate the joint capacitance and total energy stored with a steady applied potential difference of 1000V in each case.
5. Three point charges 1,2,3 coulombs are situated in free space at the corners of an equilateral triangle of side 1 m. Find the energy stored in the system.

Parallel Plate Capacitor

6. A 4mf capacitor is charged by connecting it across 100Vdc. The supply is disconnected and another uncharged 2mf capacitor is connected across it. If leakage charge is negligible determine the potential between the plates.
7. A parallel plate capacitor having area of $1 m^2$, distance between the plate 0.01m, thickness of the wood 0.002 m. The relative dielectric constant of wood is 6 times that of air. Calculate the capacitance of system.
8. Parallel plate capacitor is of area $1m^2$ and has a separation of 1mm. The space between the plates is filled with dielectric of $\epsilon_r = 25$. If 1000 V is applied, find the force squeezing the plates together.

Cylindrical Capacitor

9. Two concentric cylindrical conductor with radii $r_a=0.01\text{m}$ and $r_b=0.08\text{m}$ have charge densities $\rho_{sa} = 40\text{pC}/\text{m}^2$ and ρ_{sb} such that 'D' and 'E' fields exist between the two cylinders, but are zero elsewhere. Find ρ_{sb} .

Spherical Capacitor

10. Obtain the capacitance of a conducting sphere of 2cm in diameter, which is covered by an another medium with $\epsilon_r = 2.26$ and 3 cm thick.

Solenoid, Magnetic Moment, Polarization

11. A solenoid 25cm long, 1 cm mean diameter of the coil turns uniformly distributed windings of 2000 turns. The solenoid is placed in uniform field of 2 tesla flux density. A current of 5A is passed through the winding. Determine the (1) Maximum force on the solenoid (2) Maximum torque on the solenoid and (3) Compute the magnetic moment on the solenoid.
12. A certain homogenous slab of loss-less dielectric material is characterized by electric susceptibility of 0.12 and carries a uniform electric flux density inside of $1.6\text{nC}/\text{m}^2$. Determine the value of polarization and electric field intensity.

Boundary conditions

13. A dielectric-free space interface has the equation $3x + 2y + z = 12\text{m}$. The origin side of the interface has $\epsilon_{r1} = 3.0$ and $\mathbf{E}_1 = 2\mathbf{a}_x + 5\mathbf{a}_z$ V/m. Find \mathbf{E}_2 .

Inductance

14. Calculate the inductance of a ring shaped coil having a mean diameter of 20cm. Wound on a wooden core of 2 cm diameter. The winding is uniformly distributed and contains 200 turns.
15. Calculate the inductance of a solenoid of 200 turns wound tightly on a cylindrical tube of 6cm diameter. The length of the tube is 60cm and the solenoid is in air.

Dielectric Strength

16. A parallel plate capacitor with separation of 1cm has 29kV applied, when air was the dielectric used. Assume that the dielectric strength of air as 30kV/cm. A thin piece of glass with $\epsilon_r = 6.5$ with a dielectric strength of 290kV/cm with thickness 0.2cm is inserted. Find whether glass or air will break.

Parallel Plate Capacitor

17. The capacitance of the conductor formed by the two parallel metal sheets, each 100 cm^2 , in area separated by a dielectric 2 mm thick is $2 \times 10^{-4} \mu\text{F}$. A potential of 20kV is applied to it. Find,
- (1) Electric flux
 - (2) Potential gradient in kV/m
 - (3) The relative permittivity of the material
 - (4) Electric flux density