

Paper II- Electromagnetism

Unit I

1. Write Gauss's law in differential and integral form?
2. Define the gradient of a scalar field.
3. Scalar field is represented by the following equation

$$V = 4yz^3 + 3xyz - z^2 + 2$$

Calculate field at the point (0,-3, 1).

4. What is an electric dipole and dipole moment?
5. Define potential energy of a system.

Prove that $\nabla \cdot \mathbf{r} = r$ (a) State and prove Stoke's curl theorem?

(b) The electric potential in a field is given by the following formula

$$V = 343/r \text{ volt.}$$

Calculate the electric field at the position at $\mathbf{r} = (3\mathbf{i} + 2\mathbf{j} + 6\mathbf{k})$ meter?

6. (a) Derive formulae for essential energy required to build a sphere of uniform charge Q and radius R.

(b) A dipole moment of HCl molecule is 3.4×10^{-30} coulomb-m. Find the distance between H^+ and Cl^- ions.

7. Show that the potential at a distance R due to an arbitrary charge distribution can be an arbitrary charge can be expressed as

$$V = 1/4\pi\epsilon_0 (P_0/R + P_1/R^2 + P_2/R^3 + \dots)$$

8. State & Prove Gauss's divergence theorem.

9. Prove that curl of a conservative field is always zero.

10. Define curl of a vector. Derive the expression of curl in Cartesian coordinate system. Discuss its physical significance.

11. (i) Deduce a relation for classical radius of an electron.

(ii) Calculate the required amount of energy to build a sphere of radius 6.6×10^{-15} m having 70 e charge on it.

12. Derive the expression for the energy stored in a system of point charges.

13. State Laplace's and Poisson's equations in electrostatics.

14. What physical quantity does Laplace's equation describe in electrostatics?

15. Under what condition does Poisson's equation reduce to Laplace's equation

16. Derive Poisson's equation from Gauss's law in differential form.

17. Derive Laplace's equation from Poisson's equation.

18. Solve Laplace's equation for a 1D potential $V(x)$ in a region $0 < x < L$ with boundary conditions $V(0) = 0$, $V(L) = V_0$.
19. Calculate the gradient of the scalar field $\phi(x, y, z) = x^2 + y^2 + z^2$
20. Find the divergence of the vector field $\mathbf{A} = x^2\mathbf{i} + y^2\mathbf{j} + z^2\mathbf{k}$
21. Compute the curl of the vector field $\mathbf{A} = y\mathbf{i} + z\mathbf{j} + x\mathbf{k}$
22. Show that the divergence of the curl of any vector field is zero.
23. Verify if $\mathbf{F} = \nabla \phi$ is an irrotational field. Justify your answer
24. Prove the vector identity: $\nabla \cdot (\nabla \times \mathbf{A}) = 0$

UNIT - II

25. What is the difference between insulator and dielectric medium.
26. What are polar and non polar molecules?
27. What are free and bound charges?
28. Define atomic polarizability, electric susceptibility and electric displacement.
29. Two point charges $+q$ and $-q$ are placed at a distance $2a$ apart. Find the electric dipole moment and derive the expression for the electric field on the axial and equatorial line.
30. (i) Determine the electric field inside a polarized dielectric and hence derive the Gauss's law.
(ii) Determine the dielectric constant and susceptibility of diamond. Its permittivity is given by $1.416 \times 10^{-10} \text{ C}^2 \text{ m}^{-2} \text{ N}^{-1}$.
31. A spherical conductor of radius R carries a charge Q . What is the potential and electric field inside and outside the sphere?
32. Prove that intensity of electric field acting on an atom of the dielectric is
$$E_{\text{eff}} = E + P/3\epsilon_0$$
33. Derive Clausius-Mossotti equation for a dielectric medium.
34. Establish relation between dipole moment and atomic polarizability.
35. Establish the following relation:

(i) $D = \epsilon_0 E + P$

(ii) $\epsilon_r = 1 + \chi$

UNIT -III

36. What is Lorentz's force?
37. Use Biot–Savart law to derive the magnetic field at the center of a circular current loop.
38. Derive the expression for the magnetic field on the axis of a solenoid
39. (a) What do you understand by bound current and free current with regards to magnetic effect? Prove that the curl of magnetization field is equal to free surface current density?
(b) Using above relation, establish the following.
- a. $B = \mu_0(H + M)$
 - b. $\mu = \mu_0(1 + X)$
40. Define magnetic field. Write its dimension and properties?
41. Define Bohr magneton. Find its value?
42. Define Biot Savart's law.
43. Define magnetic susceptibility and magnetic permeability and write down the relation between them.
44. Define orbital gyromagnetic ratio and prove that magnetic moment due to orbital motion of an electron must be an integer multiple of $eh/4\pi m$. where symbols have usual meaning.
45. What happens to a charged particle moving parallel to a magnetic field?
46. A proton moves perpendicular to a uniform magnetic field. What is the shape of its path and why?
47. Determine the magnetic induction inside and outside a long hollow thin current carrying cylinder. Plot magnetic field with distance from the axis of the cylinder.
48. (i) Derive an expression of Poynting vector and explain its physical significance.
(ii) Laser rays of 50 W are concentrated with the help of a lens at 10^{-10} m^2 cross sectional area. Calculate the value of Poynting vector.
49. What is magnetic susceptibility? How does it differ for diamagnetic, paramagnetic, and ferromagnetic materials.
50. Describe the behavior of atomic magnetic dipoles in diamagnetic, paramagnetic, and ferromagnetic materials.
51. Explain the temperature dependence of magnetic susceptibility in paramagnetic and ferromagnetic materials.
52. State Curie's Law for paramagnetism and define Curie constant.
53. What is meant by magnetic hysteresis? How is it related to ferromagnetic materials?
54. Compare the magnetic permeability of diamagnetic, paramagnetic, and ferromagnetic materials

55. Explain how diamagnetism arises from Lenz's law and induced currents in electron orbits.

UNIT - IV

56. Write Maxwell's equations in differential form and explain the physical meaning of each.

57. Show that electromagnetic waves are transverse in nature.

58. Derive the wave equation for electric and magnetic fields in free space using Maxwell's equations.

59. Write Maxwell's equation, use these equation to show the electromagnetic wave for non-conductor isotropic medium and to show that electric fields E is satisfy following wave equation.

$$\nabla^2 \mathbf{E} = \mu_0 \epsilon \partial^2 \mathbf{E} / \partial t^2$$

Obtain the formula of refractive index of the medium and also discuss validity of this formula?

60. What is displacement current? Discuss its properties?

61. Write down Maxwell's equation in differentiation and integral form with their physical significance?

62. What do you mean by energy density of electromagnetism waves and give significance of pointing vector?