

2023
B.A./B.Sc.
Second Semester
GENERIC ELECTIVE – 2
PHYSICS
Course Code: PHG 2.11
(Electricity & Magnetism)

Total Mark: 70
Time: 3 hours

Pass Mark: 28

Answer five questions, taking one from each unit.

UNIT-I

1. (a) Discuss geometrical interpretation of dot product of two vectors. 3
(b) What is the scalar product of a vector with itself? Express scalar product of two vectors in terms of their rectangular components. 3
(c) What is divergence of a vector field? If ϕ is a scalar field and \vec{A} is a vector field, find the value of $\text{div} \phi(\vec{A})$. 4
(d) For a vector $\vec{A} = 2x^2y\hat{i} + 3yz\hat{j} + x^2y^2z^2\hat{k}$, find curl \vec{A} at the point $(1, -2, 0)$. 4
2. (a) Discuss surface integral of a vector function. 4
(b) What is the vector product of a vector with itself? Express vector product of two vectors in terms of their rectangular components. 3
(c) Calculate grad r where $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$. 4
(d) A vector $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$. Prove that $\iiint_S \vec{r} \cdot d\vec{s} = 3V$ where V is the volume enclosed by the surface S . 3

UNIT-II

3. (a) What is electrostatic field? Derive the expression of electrostatic field when the source charge is placed at the origin and also when the source charge is placed at any arbitrary point. 4

- (b) Using Gauss's law, find the electric field due to a uniformly charged spherical shell. 5
- (c) What is electric flux? Give the expression of electric flux for uniform electric field. 2
- (d) A charge $q_1 = 4\mu\text{C}$ is located at the origin of a coordinate system. Another charge $q_2 = 1\mu\text{C}$ is placed at a distance of 0.2 m from the origin along the x -axis. Find the location at which the electric field due to these charges is zero. 3
4. (a) What is electrostatic potential? Express electric field as a gradient of potential. 4
- (b) Derive the expression of electrostatic potential due to a uniformly charged non conducting solid sphere. 5
- (c) What is electric dipole? Define electric dipole moment. 2
- (d) A dipole consisting of charges -3.0 nC and $+3.0\text{ nC}$ separated by a distance of 5.0 mm is situated in a uniform electric field of $6.0 \times 10^5\text{ NC}^{-1}$ at an angle 30° with the field. Calculate the dipole moment. 3

UNIT-III

5. (a) Define capacitance. Derive the expression of capacitance of parallel plate capacitor held in air. 4
- (b) Derive the expression of capacitance of spherical capacitor. 4
- (c) Obtain the expression of energy stored in a capacitor. 3
- (d) Two cylindrical capacitors are of equal length and filled with the same dielectric. The radii of the inner and outer cylinders of one capacitor are 8 cm and 10 cm respectively while that of the other capacitor are 7 cm and 9 cm respectively. Find the ratio of their capacitance. 3
6. (a) What is dielectric constant? Express it mathematically. 2
- (b) Proof the integral and differential form of Gauss's law in dielectrics. 6
- (c) Discuss the behaviour of electric field in matter and define electric polarisation of dielectric medium. 3

- (d) At what distance should the two plates each of surface area $0.2 \text{ m} \times 0.1 \text{ m}$ of an air capacitor be placed in order to have the same capacitance as an isolated conducting sphere of radius 0.5 m ? 3

UNIT-IV

7. (a) Using Biot-Savart's law, obtain the expression of magnetic field due to a straight wire. 5
 (b) What is a solenoid? Derive the expression of magnetic field due to an infinitely long solenoid carrying current. 6
 (c) In an atom, an electron circulates in a path of radius $5.1 \times 10^{-11} \text{ m}$ at a frequency of $6.8 \times 10^{15} \text{ rps}$. What is the value of magnetic field at the centre of the orbit? 3
8. (a) What are free and bound current? Briefly describe magnetisation. 4
 (b) Define magnetic intensity, magnetic susceptibility, and magnetic permeability. Obtain the relation between relative permeability and susceptibility. 5
 (c) State two properties of ferromagnetic materials. 2
 (d) The magnetic susceptibility of a certain specimen is $950 \times 10^{-11} \text{ Hm}^{-1}$. Calculate relative permeability and permeability if $\mu_0 = 12.57 \times 10^{-7} \text{ Hm}^{-1}$. 3

UNIT-V

9. (a) What is self induction? Derive the expression of induced emf in self induction and define one henry. 5
 (b) Discuss the concept of displacement current by showing how Maxwell modified Ampere's law. 9
10. (a) What is Poynting vector? Prove that electromagnetic waves propagates in the direction of Poynting vector. 5
 (b) Derive the expression of electromagnetic wave equation for electric field and magnetic field through a conducting median. 9