2024

B.A./B.Sc.

Second Semester

GENERIC ELECTIVE – 2

PHYSICS

Course Code: PHG 2.11

(Electricity & Magnetism)

Total Mark: 70 *Pass Mark: 28*

Time: 3 hours

Answer five questions, taking one from each unit.

UNIT–I

1. (a) Write six properties of scalar product of vectors. 3

   (b) Describe gradient of a scalar field. Discuss the physical significance of gradient of a scalar field and show that gradient of a scalar field is a vector. 3+4+2 = 9

   (c) If $\phi = x^3 + y^4 + z^2$, find $\vec{\nabla}\phi$. 2

2. (a) What is divergence of a vector field? Explain its physical significance. 2+2=4

   (b) Explain line integral of a vector function. 4

   (c) Find the value of $\vec{\nabla} r^n$ where $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$. 3

   (d) If $\vec{E} = (x+y)\hat{i} + (y-2x)\hat{j} - 2z\hat{k}$, find *curl* $\vec{E}$ and *div* $\vec{E}$. 3

UNIT–II

3. (a) State and prove Gauss' law in electrostatics. 1+3=4

   (b) Using Gauss' law, find the electric field due to a uniformly charged solid sphere. 6

   (c) What is area vector? Define electric flux. 1+1=2

   (d) An infinite line charge produces a field of $4.52\times10^4\,NC^{-1}$ at a distance of 1.96 m. Calculate the linear charge density. 2

4. (a) Derive the expression of electrostatic potential due to a dipole. 7
   (b) For a uniformly charged spherical shell. Find the electrostatic potential at a point outside, on the surface and inside the shell. 4
   (c) The electrostatic potential due to a point charge q at a distance r is given by $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$. Find the expression of electric field intensity. Calculate electric field intensity if $q = 4$ C and $r = 2$ m. 3

UNIT–III

5. (a) Prove that $\vec{D} = \varepsilon_0\vec{E} + \vec{P}$, where the symbols have their usual meaning. 4
   (b) What is susceptibility? Obtain the relationship between dielectric constant and susceptibility. 3
   (c) Write the mathematical formula of capacitance and show that for an isolated conducting sphere, the surface charge density will be larger in regions of higher curvature. 4
   (d) Find the capacitance of a parallel plate capacitor of sides 0.055 m and 0.04 m and filled with a dielectric of thickness 0.4 mm and dielectric constant 2. The two plates are separated by a distance of 0.7 mm in air. 3

6. (a) Obtain the expression of capacitance of a parallel plate capacitor filled with composite dielectric. What will happen to capacitance when the parallel plate capacitor is partially filled with a single dielectric slab ? 7
   (b) Derive the expression of capacitance of cylindrical capacitor. 4
   (c) A capacitor charged from a 50 V d.c. supply is found to have a charge of 10 μC. What is the capacitance of the capacitor and how much energy is stored in it? 3

UNIT–IV

7. (a) State Biot Savart's law and express it in vector form. 2
   (b) Using Biot Savart's law, obtain the expression of magnetic field due on the axis of a circular current loop. 6

(c) Why magnetic monopole do not exist? Write the significance of divergence and curl of a magnetic field? 3

(d) A solenoid is 2.0 m long and 3.0 cm in diameter. It has 5 layers of winding of 1000 turns each and carries a current of 5.0 A. What is the magnetic field at its centre. 3

8. (a) Using Biot Savart's, discuss the concept of magnetic vector potential. 5

(b) State and write physical significance of Maxwell's equations. 6

(c) The permeability of a metal is measured to be 0.12 $TA^{-1}m$. Find its relative permeability and susceptibility. 3

UNIT–V

9. (a) What is electromagnetic induction? How can it be produced? 3

(b) What is mutual induction? Derive the expression of induced e.m.f. in mutual induction and define one Henry. 5

(c) Derive the equation of continuity of current. 4

(d) If a rate of change of current of 4 As^{-1} induces an e.m.f. of 20 mV in a solenoid, what is the self-inductance of the solenoid? 2

10. (a) Show that electromagnetic waves are transverse in nature. 5

(b) Prove that the energy density of electromagnetic wave in dielectric is ε_r times the energy density of the same wave in vacuum. 4

(c) State the four Maxwell's equations. 2

(d) The magnetic flux through a coil perpendicular to its plane is varying according to the relation $\phi = \left(5t^3 + 4t^2 + 2t - 5\right)$ weber. Calculate the induced current through the coil at $t = 2$ s, if the resistance of the coil is 5 Ω. 3
