2022

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 <u>five</u> *questions, taking* <u>one</u> *from each unit.*

UNIT–I

1. (a) If $\vec{A} = \hat{i} + 2\hat{j} + 2\hat{k}$ and $\vec{B} = 2\hat{i} + \hat{j} - \hat{k}$, find the magnitude of $\vec{A} \times \vec{B}$.

        3

   (b) What is gradient of a scalar field? Find the value of $\vec{\nabla} r^n$, where

        $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$.   1+4=5

   (c) What is the scalar product of a vector with itself? Discuss physical significance of gradient of a scalar field.   1+5=6

2. (a) If $\vec{P} = x^3 z\hat{i} + 3y^2 z^2 \hat{j} - 4xyz^2 \hat{k}$, find $div\vec{P}$ at the point $(2, -1, 1)$.

        3

   (b) What is curl of a vector field? If $\vec{E} = (x + y)\hat{i} + (y - 2x)\hat{j} - 2z\hat{k}$,

        find $curl\vec{E}$ and $div\vec{E}$.   1+2+2=5

   (c) Discuss the physical significance of divergence and curl of a vector field.   6

UNIT–II

3. (a) Two point charges of 2×10^{-7} C and 1×10^{-7} C are placed 1 cm apart. What is the magnitude of the field produced by either charge at the site of the other?   3

(b) State and prove Gauss' law. 5

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

4. (a) At a point due to a charge, the values of electric field intensity and potential are $32\ NC^{-1}$ and $16\ JC^{-1}$ respectively. Calculate magnitude of charge and distance of the charge from the point of observation. 4

(b) Find the electrostatic potential due to a uniformly charged solid shell. 5

(c) Prove that the electrostatic potential due to a dipole is

$$V = \frac{1}{4\pi\varepsilon_0}\frac{p\cos\theta}{r^2},$$ where the symbols have their usual meaning. 5

UNIT–III

5. (a) What is a capacitor? Write the expression of capacitance of an isolated conductor and show that for an isolated conducting sphere, the surface charge density will be larger in regions of higher curvature. 1+1+2=4

(b) Two parallel plate air capacitors have their plate areas of $100\ cm^2$ and $500\ cm^2$ respectively. If they have the same charge and potential, and the distance of separation between the plates of the first capacitor is 0.5 mm, what is the distance of separation between the plates of the second capacitor? 4

(c) Find the capacitance of a parallel plate capacitor filled with composite dielectric. How will the capacitance change when it is filled with a single dielectric slap? 6

6. (a) The plates of a parallel plate capacitor have an area of $90\ cm^2$ each and are separated by 2.5 mm. The capacitor is charged by connecting it to a 400 volt supply. How much electrostatic energy is stored by the capacitor? 4

(b) Derive the expression of capacitance of a cylindrical capacitor. 5

(c) What is polarization in dielectrics? Show that $D = \varepsilon_0 E + P = \sigma$, where the symbols have their usual meaning in dielectrics. 5

UNIT–IV

7. (a) The length of a solenoid is 0.2 m and it has 120 turns. Find the magnetic field in its interior, if a current of 2.5 A is flowing through it.

    3

   (b) State and prove Ampere's circuital law. Express Ampere's circuital law in differential form.   5

   (c) Derive the expression of magnetic field on the axis of a circular loop.

    6

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

   (b) Using Biot-Savart's law, discuss the concept of magnetic vector potential.   5

   (c) Obtain the relation between magnetization current density vector $\vec{J}$ and magnetization vector $\vec{M}$ and prove that $\vec{B} = \mu_0 \left(\vec{H} + \vec{M} \right)$, where the symbols have their usual meaning.   3+3=6

UNIT–V

9. (a) Define magnetic flux and state Faraday's laws of electromagnetic induction.   3

   (b) Deduce the expression of energy stored in a magnetic field.   3

   (c) 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. Find the induced emf in the coil.   3

   (d) Derive the equation of continuity of current.   5

10. (a) Electromagnetic waves travel in a medium with a speed of 2×10^8 ms^{-1}. If the relative permeability of the medium is 1, find the relative permittivity of the medium.   3

   (b) Describe how Maxwell modified Ampere's circuital law for varying currents.   5

(c) What is a plane polarized electromagnetic wave? Obtain the wave equation for plane polarized electromagnetic wave in the free space and prove that $\dfrac{E_o}{H_o} = \sqrt{\dfrac{\mu}{\varepsilon}}$, where the symbols have their usual meaning.　　6

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