U.G. 2nd Semester Examination - 2023

PHYSICS

[HONOURS]

Course Code : PHY-H-CC-T-03

(Electricity and Magnetism)

Full Marks : 40

Time : $2\frac{1}{2}$ Hours

The figures in the right-hand margin indicate marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP–A

1. • Answer any **five** questions: $2 \times 5 = 10$

   a) The electric field at any point (x,y,z) in free space is $\vec{E} = x\hat{i} + y\hat{j} + z\hat{k} \, Vm^{-1}$. Find the charge density $\rho(x,y,z)$.

   b) Chek whether the vector $\vec{E} = y^2\hat{i} + (2xy + z^2)\hat{j} + 2yz\hat{k}$ represents an electrostatic field or not.

   c) The electrostatic potential in free space is given by $\varphi(x,y) = \alpha - \beta(x^2+y^2) - \gamma \ln\sqrt{x^2 + y^2}$, where α, β and γ are constants. Find the electric field and charge density in this region.

[Turn Over]

d) What do you mean by hysteresis in a ferromagnetic material?

or What is self-inductance?

f) What is meant by complex reactance and impedance?

g) Define current and charge sensitivities of a ballistic galvanometer.

h) Show that the electrostatic self energy of a uniformly charged sphere is $\frac{1}{4.7\,\epsilon_0}\frac{3Q^2}{a}$.

where 'a' is the radius of the sphere, and Q is the charge on the sphere.

GROUP-B

2. Answer any two questions: $5 \times 2 = 10$

a) Consider a point charge $+q$ in front of a conducting sphere of radius 'a' at distance 'f' from the centre. Find (i) the value of the image charge (ii) location of the image charge. What is linear dielectric? Give example. $3+2$

b) Starting from Gauss's law derive Poisson's equation in dielectric and hence deduce the Laplace's equation. What is magnetic vector potential? $1+3+1$

c) What is the magnetic field due to a wire of length element dl carrying current I at a distance R from the wire? Calculate the magnetic field at the centre of a circular ring of radius 'a' carrying current I.   1+4

d) Calculate the capacitance of a cylindrical capacitor of internal and external radii 'a' and 'b' respectively and of length 'l', the space being filled by a medium of dielectric constant 'ε'.

5

GROUP-C

Answer any **two** questions: $10 \times 2 = 20$

3. a) What is magnetic vector potential? Find an expression of the magnetic vector potential for a volume current distribution.   ④

   b) An electric dipole of moment $\vec{P}$ is placed in non-uniform electric field $\vec{E}(x, y, z)$. Calculate the net force acting on the dipole.   3

   c) A conducting wire of length 2m and parallel to y-axis is in a uniform magnetic field B. The wire carries a current 10A in the negative y-direction and experience a force $10^{-2}\left(-\hat{i}+\hat{k}\right)$. Find the x and z component of $\vec{B}$. (1+3)+3+3

4. a) State Ampere's circuital law. Using this law show that the magnetic field for a toroid of 'n' turn is $B = \mu_0 n I$, where I is the current flow through the toroid. Show that the magnetic field outside the toroid is zero.

b) How does the hysteresis curve for a sample of ferromagnetic material determine its suitability for use as (i) an electromagnet (ii) a permanent magnet?

c) What is electromagnetic damping in a ballistic galvanometer? What are the factors on which it depends? $(1+2+1)+(2+2)+(1+1)$

5. a) Calculate mutual inductance between two parallel co-axial coil of radius 'a', having 'n' turns in both of them and separated at a distance 'd'.

b) A series LCR circuit is driven by a sinusoidal voltage. Find out the impedance of the circuit. What is the resonance condition? What is value of power factor at resonance? $4+(4+1+1)$

6. a) State Thevenin's theorem. Find the Norton equivalent circuit between 'a' and 'b' for the following network:
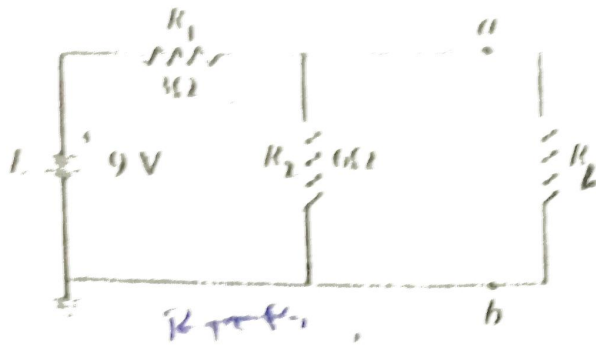
Also find out the condition for maximum power transfer in the circuit.

b) State and explain reciprocity theorem. What are the limitations of reciprocity theorem?

c) What do you mean by ideal constant-voltage and constant-current sources.

$$(1+2+2)+(2+1)+(1+1)$$

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