

2023

PHYSICS

Paper : PHYHC2036

(Electricity and Magnetism)

Full Marks : 60Pass Marks : 24

Time : 3 hours

The figures in the margin indicate full marks
for the questions

1. Choose the correct answer (any five) : 1×5=5

(a) Dimension of electric flux is

(i) $[ML^3T^{-2}A^{-1}]$

(ii) $[ML^3T^{-3}A^{-1}]$

(iii) $[M^0L^1T^{-3}A^{-2}]$

(iv) $[ML^3T^{-2}A^{-2}]$

(b) Poisson's equation is

(i) $\vec{\nabla} \cdot \vec{E} = \rho / \epsilon_0$

(ii) $\nabla^2 V = 0$

(iii) $\nabla^2 V = -\rho / \epsilon_0$

(iv) $\vec{\nabla} \times \vec{E} = \rho / \epsilon_0$

(c) The work done on a unit positive charge in bringing it from infinity to any point in an electric field is called

(i) intensity at that point

(ii) electric potential at that point

(iii) electric potential at infinity

(iv) electric intensity at infinity

(d) Divergence of magnetic field is

(i) 0

(ii) $\mu_0 \vec{j}$

(iii) $-\mu_0 \vec{j}$

(iv) $\vec{\nabla} \times \vec{A}$

(e) The magnetic field measured at the centre of a current-carrying circular loop of radius R is

(i) $\frac{I}{2\pi\mu_0 R}$

(ii) $\frac{\mu_0 I}{2R}$

(iii) $\frac{\mu_0 I}{2\pi R}$

(iv) $\frac{\mu_0 I}{2\pi R^2}$

- (f) A current-carrying loop can be treated as
- (i) electric dipole
 - (ii) magnetic dipole
 - (iii) electric monopole
 - (iv) magnetic monopole
- (g) Ballistic galvanometer measures
- (i) current
 - (ii) charge
 - (iii) potential
 - (iv) capacitance
- (h) In a parallel L - C - R resonant circuit, the value of current at resonance is
- (i) minimum
 - (ii) maximum
 - (iii) zero
 - (iv) sometimes minimum and sometimes maximum
- (i) The energy stored in a magnetic field is given by
- (i) $U = \frac{1}{2}LI^2$
 - (ii) $U = \frac{1}{2}LI$
 - (iii) $U = LI^2$
 - (iv) $U = LI$

- (j) Gauss' law in differential form is
- (i) $\vec{\nabla} \times \vec{E} = 0$
 - (ii) $\vec{\nabla} \times \vec{E} = \rho / \epsilon_0$
 - (iii) $\vec{\nabla} \cdot \vec{E} = 0$
 - (iv) $\vec{\nabla} \times \vec{E} = -\rho / \epsilon_0$

2. Answer any five of the following questions:

2×5=10

- (a) State and explain Biot-Savart law.
- (b) Define electrical susceptibility and dielectric constant.
- (c) Derive the relation $D = \epsilon_0 E + P$.
- (d) Write the difference between diamagnetic and ferromagnetic substances.
- (e) Show that

$$V = q / 4\pi\epsilon_0 \sqrt{x^2 + y^2 + z^2}$$

satisfies Laplace's equation.

- (f) State superposition theorem and maximum power transfer theorem.
- (g) The vector potential in a region is $\vec{A} = -y\hat{i} + 2x\hat{j} + 3z\hat{k}$. Calculate the associated magnetic induction $\vec{B}$.

(5)

3. Answer any *five* of the following questions :

5×5=25

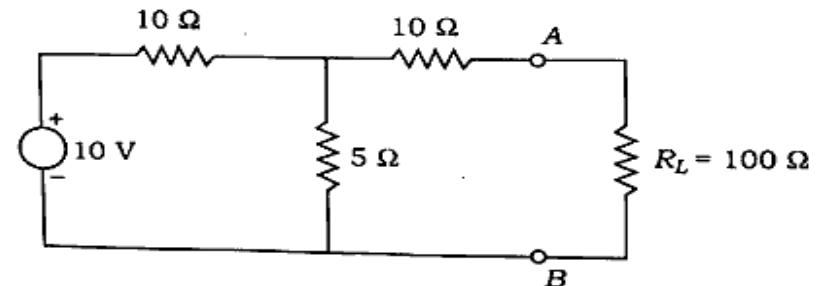
- (a) Derive an expression for field and potential due to an electric dipole.
- (b) State and establish Gauss' law in dielectrics.
- (c) State and explain Norton's theorem.
- (d) Derive an expression for magnetic field due to an infinitely long current-carrying solenoid using Amperes circuital law.
- (e) Define power factor and wattless current in an a.c. circuit. Derive an expression for power factor for an a.c. circuit containing L , C and R in series.
- (f) Find divergence and curl of a magnetic field B .
- (g) State and prove second uniqueness theorem.
- (h) Explain reciprocity theorem of mutual inductance.
- (i) Applying Biot-Savart law, derive an expression for magnetic field due to a straight wire carrying current.

(6)

4. Answer any *two* of the following questions :

10×2=20

- (a) Derive an expression for magnetic force on current-carrying conductor. Calculate the magnetic force between two straight long current-carrying wires when the currents flow in opposite direction and hence define one ampere current from it. 5+5=10
- (b) (i) What do you mean by current and charge sensitivity of a ballistic galvanometer? Derive an expression for torque of a current loop in a magnetic field. 5
- (ii) Use Thevenin's theorem to find the current in $R_L = 100 \Omega$ in the following circuit : 5



- (c) (i) Derive an expression for capacitance of an isolated conducting sphere of radius a . 5

(ii) What is an electric image? A point charge $+q$ is placed in front of an infinitely conducting plane connected to earth. Using electrical image method, find the electric field—

(1) at a point on the plane;

(2) at any point near the conducting plane.

5

(d) (i) What is hysteresis? Prove that

$$\vec{B} = \mu_0 (\vec{H} + \vec{M})$$

1+4=5

(ii) State and explain Lenz's law of electromagnetic induction.

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