

R=11 (Red)

Z(2nd Sm.)-Physics-H/CC-3/CBCS
(Syllabus : 2019-20 & 2018-19)

2023

PHYSICS — HONOURS

[Syllabus : 2019-2020 & 2018-2019]

Paper : CC-3

(Electricity and Magnetism)

Full Marks : 50

The figures in the margin indicate full marks.

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

Answer **question no. 1** and **any four** questions from the rest.

1. Answer **any five** questions :

2×5

(a) Starting from Gauss's law obtain Poisson's equation in terms of electrostatic potential.

(b) Show that $\vec{\nabla} \cdot \frac{\vec{r}}{r^3} = 4\pi\delta(\vec{r})$.

(c) Check whether the following field is a possible electrostatic field.

$$\vec{E} = A \left[2xz\hat{i} - yz^2\hat{j} + (1 + y^2z)\hat{k} \right],$$

where the symbols have their usual meaning.

(d) Prove that magnetic forces do not work.

(e) A long straight conductor carries a current I . Determine the force per unit length on the conductor when it is placed in an uniform magnetic field.

(f) Write down Maxwell's electromagnetic field equations in free space explaining the symbols.

(g) What is meant by resonance in series LCR circuit?

2. (a) A positive charge Q is divided into two positive point charges q_1 and q_2 . Show that, for a given separation, the force exerted by one charge on the other is greatest if $q_1 = q_2 = \frac{Q}{2}$.

(b) State and explain Gauss's law in dielectric medium.

(c) Find the charge density in a region, where the potential is

$$V = a - b(x^2 + y^2) - c \log \sqrt{x^2 + y^2};$$

where a, b, c are constants.

(d) What is meant by dipole moment of an electric dipole? Find the mutual potential energy of two dipoles of equal moment 6×10^{-30} C.m lying along the same line at a separation of 3×10^{-10} m.

2+2+3+(1+2)

Please Turn Over

3. (a) Find the electric field at a distance Z above the centre of a circular ring of radius R , which carries a uniform line charge density λ . What will be the value of electric field when $Z \gg R$? Comment on your result.
- (b) There is an infinite, grounded conducting plane forming $x-y$ plane and a point charge $+q$ is placed on the z -axis at $z = d$. Find out the potential and field in the region $z \geq 0$ using the method of images. (4+1+1)+4
4. (a) A spherical Gaussian surface encloses a charge $8.85 \times 10^{-8} \text{ C}$ in air. The total outward flux through the surface is $10^4 \text{ Nm}^2 \text{ C}^{-1}$. Determine the value of permittivity of air. If the radius of the Gaussian surface is doubled, how would the flux change?
- (b) Find the electrostatic energy of a charged sphere of radius R and total charge Q .
- (c) Define electric polarization. Find its unit in SI system. (2+1)+5+(1+1)
5. (a) Consider a circular loop of radius R carrying a current I . Calculate the magnetic field at any axial point at a distance x from the centre of the loop.
- (b) Starting from Biot-Savart law, show that the divergence of magnetic field is zero.
- (c) Write down the Boundary conditions of \vec{B} and \vec{H} , where the symbols have their usual meaning. 5+3+2
6. (a) Compare two properties of diamagnetic, paramagnetic and ferromagnetic materials.
- (b) Deduce the relationship between magnetization \vec{M} and magnetization current density \vec{J}_m .
- (c) Establish Faraday's law of electromagnetic induction in differential form.
- (d) Derive the equation of continuity from the principle of conservation of charge. 3+3+2+2
7. (a) The equivalent inductances of two inductors are 2.4 mH when connected in parallel and 10 mH when connected in series. Determine the difference between their inductance.
- (b) An LCR series circuit is connected to a source of a sinusoidal e.m.f. of angular frequency ω and peak value V_0 . Find the current in the circuit. What is the phase difference between the voltage and the current? Under what condition does the voltage lead the current?
- (c) Determine the value of impedance in the following circuit : 3+(3+1+1)+2

