[This question paper contains 4 printed pages.]

**Your Roll No.....**

**Sr. No. of Question Paper : 5806** **J**

Unique Paper Code : 2222011202

Name of the Paper : Electricity and Magnetism

Name of the Course : **B.Sc. Hons. (Physics) NEP: UGCF-2022**

Semester : II

Duration : 3 Hours Maximum Marks : 90

**Instructions for Candidates**

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all, including Question No. **1** which is compulsory.
3. **All** questions carry equal marks.

1. Answer **any 6** of the following : (6×3=18)

   (a) Find $V_{ab}$ in an electric field $\vec{E} = 2\hat{i} + 3\hat{j} + 4\hat{k}$ N/C where $\vec{r}_a = \hat{i} - 2\hat{j} + \hat{k}$ m and $\vec{r}_b = 2\hat{i} + \hat{j} - 2\hat{k}$ m.

   (b) State the Second uniqueness theorem.

   (c) What is the work required to bring a charge q from infinity to a distance d above a grounded conducting plane?

   (d) At the boundary of two dielectric materials, material 1 has $\epsilon_1 = 2\epsilon_0$, and material 2 has $\epsilon_2 = 4\epsilon_0$. If $e_1^{\perp} = 6$ V/m, what is $\epsilon_2^{\perp}$, assuming no free surface charge?

   (e) A solenoid of length 0.5 m and 1000 turns per meter carries a current of 2 A. Find the magnetic field inside the solenoid.

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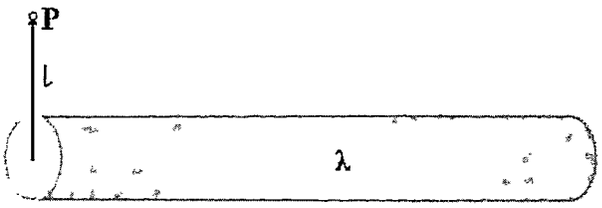
(f) A material placed in a field H = 800 A/m shows a M = –0.08 A/m. Find its magnetic susceptibility $\chi_m$. What type of material is it?

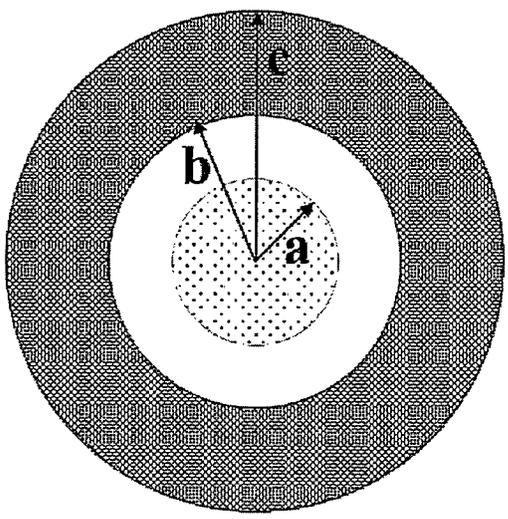
(g) A cylindrical conductor of uniform cross section, has a voltage drop of 2.0 V along its 100 m length and a current density of $5.0 \times 10^5$ A/m$^2$. What is the conductivity of the material in the conductor?

2. (a) A half-infinite line has linear charge density λ. Find the electric field at a point that is "even" with the end, a distance *l* from it, as shown in Figure. (8)




(b) Prove that electrostatic field is negative of gradient of electrostatic potential. (2)

(c) State Ampere's law. The coaxial line shown in Figure below carries the same current i up the inside conductor of radius a and down the outer conductor of inner radius b & outer radius c.




Find the magnetic field at all distances r from the center of the conductor. (8)

3. (a) Let a charge q be distributed over a sphere of radius R with a constant volume charge density $\rho$, and thus for $r > R$ the charge density is zero. Applying the Laplace's or Poisson equations, find the electrostatic potential inside $r < R$ and outside $r > R$ the sphere. (8)

(b) For the above system, find the electrostatic field on the surface of the sphere. (2)

(c) What do you understand by magnetization and magnetic polarization of the material? Derive expressions for differential and integral form of Ampere's law in the presence of magnetized materials. (8)

4. (a) A point charge q is situated a distance a from the centre of a grounded conducting sphere of radius R. Applying the method of images, find the electrostatic potential at any point outside the sphere. (8)

(b) The electric field in a region is given by $\vec{E} = x\hat{i}$. Find the total flux passing through a cube bounded by the surfaces, $x = 1$, $x = 2$, $y = 0$, $y = 1$, $z = 0$ and $z = 1$. (2)

(c) Write down the four fundamental Maxwell equations in the differential form along with their explanations. Also, comment on their significance. (8)

5. (a) A sphere of radius R carries a polarization $\vec{P}(\vec{r}) = k\vec{r}$, where k is a constant and $\vec{r}$ is the vector from the center. (a) Calculate the bound charges $\sigma_b$ and $\rho_b$. (b) Find the field inside and outside the sphere. (8)

(b) Show that the potential is constant inside an enclosure completely surrounded by conducting material, provided there is no charge within the enclosure. (2)

(c) A tightly wound cylindrical coil of wire, of radius a and n turns per unit length, is usually called a solenoid. Use Biot Savart law to find the magnetic field at the point on its axis if the wire carries a current I. Consider the turns to be essentially circular and solenoid to be infinite in both directions. (8)

*P.T.O.*

6. (a) Find the magnetic field $\vec{B}$ and hence the vector potential $\vec{A}$ at a distance r from a long straight wire carrying a current I. (8)

(b) A point charge q is located d distance above an infinite grounded conducting plane. Find the direction of the electric field at the point P directly above the charge, at a height 2d from the plane. (2)

(c) State the Gauss Law in integral and differential form. Suppose the electric field in some region is found to be $\vec{E} = kr^3\hat{r}$, in spherical coordinates (k is some constant). (a) Find the charge density $\rho$. (b) Find the total charge contained in a sphere of radius R, centered at the origin. (8)