Sl. No of QP: 1283

Unique Paper Code	:	**32221201**
Name of the Paper	:	**Electricity and Magnetism**
Name of the Course	:	**B. Sc. Hons.–(Physics)_Core (Repeat Paper)**
Semester	:	**II**
Duration	:	**3 hours**
Max. Marks	:	**75 marks**

(Write your Roll number on the top immediately upon receipt of this question paper.)
Attempt FIVE questions in all. Question No. 1 is compulsory.
All questions carry equal marks

[1]

a) Can the following be a possible electrostatic field?

$$\boldsymbol{E} = 2xy\,\boldsymbol{i} + 3y\,\boldsymbol{j} - 9xz\,\boldsymbol{k}$$

b) An electric dipole is placed in a non-uniform electric field. Calculate the force acting on it.

c) Prove that $\vec{\nabla}.\vec{B} = 0$ and explain its physical significance.

d) State and prove first Uniqueness theorem.

e) Prove reciprocity theorem for mutual inductance (i.e. M_{12}=M_{21}).

(5x3=15)

[2] a) State and prove Gauss's theorem in electrostatics. Show that $\vec{\nabla}.\vec{E} = \frac{\rho}{\varepsilon_o}$.

b) A thick spherical shell carries a charge density $\rho = \frac{k}{r^2}$. The inner and outer radii of the spherical shell are a and b respectively. Find the electric field in the regions (i) $r < a$ (ii) $a < r < b$ and (iii) r > b. **(7, 8)**

[3] a) Derive an expression for potential and electric field at a point (r,θ) due to an electric dipole.

b) Using the method of images, determine the position and magnitude of the image charge of a point charge q placed in front of an earthed conducting sphere of radius R at a distance d from its center. **(7, 8)**

[4] a) What is meant by the polarization of a dielectric? Show that the polarization of a dielectric medium gives rise to a volume charge density $\rho_P = \vec{\nabla}.\vec{P}$ and surface charge density $\sigma_P = \vec{P}.n\hat{}$.

b) A capacitor is composed of n plates each having an area A and separated by d. The two end plates are connected to a battery having potential V. What charge is stored on plates? What is its capacitance? **(7, 8)**

[5] a) State Biot-Savart's law. Derive an expression for the magnetic field at a point due an infinitely long straight current carrying conductor using Biot-Savart's law.

b) Prove that the magnetic vector potential due to current carrying conductor having volume V and bounded by surface S

$$\vec{A}(\vec{r}) = \frac{\mu_0}{4\pi} \iiint_V \frac{\vec{J}(\vec{r'})}{R} dv'$$

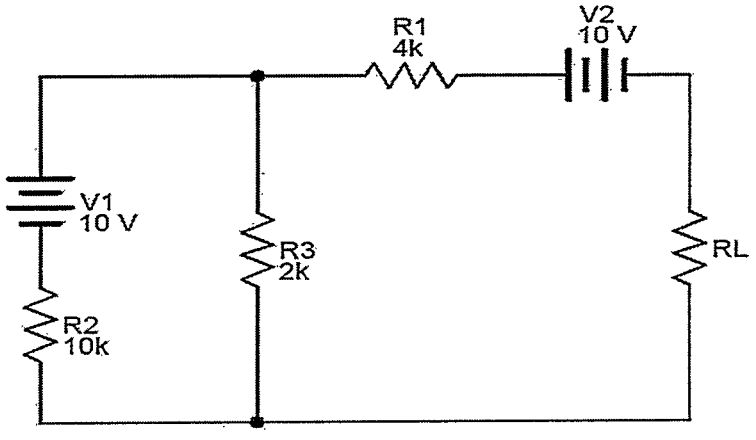
where $\vec{r'}$ is the position vector of source, $\vec{r}$ is the position vector of the observation point and $\vec{R} = \vec{r} - \vec{r'}$. **(7,8)**

[6] a) How did Maxwell modify Ampere's circuital law to make it consistent with continuity equation. Find the displacement current density in a material having $\varepsilon_r = 25$ and electric field $\boldsymbol{E} = 5 \times 10^{-6} \sin(9 \times 10^9 t)$ V/m.

b) Define mutual inductance between two coils. Show that $M = k\sqrt{L_1 L_2}$, where L_1 and L_2 are self-inductance of the two coils and parameter $k = \sqrt{k_1 k_2}$, where k_1 and k_2 are geometric factors of flux linkages between two coils. **(7, 8)**

[7] a) A series LCR circuit has $R = 10\Omega$, $L = 0.35H$ and $V = 100 \cos \pi t$. Find the value of C for resonance. Also determine the voltage across C. Plot the variation of quality factor with resistance for a series LCR circuit.

b) State maximum power transfer theorem. Draw Thevenin equivalent circuit for the following circuit and hence find the value of R_L for which the power transfer is maximum.



(7, 8)

Useful Constants

$\epsilon_0 = 8.85 \times 10^{-12} C^2 N^{-1} m^{-2}$

$\mu_0 = 4\pi \times 10^{-7} NA^{-2}$