U.G. 2nd Semester Examinations 2022

PHYSICS (Honours)

Paper Code : DC-3T

(Electricity and Magnetism)

Full Marks : 25 Time : Two Hours

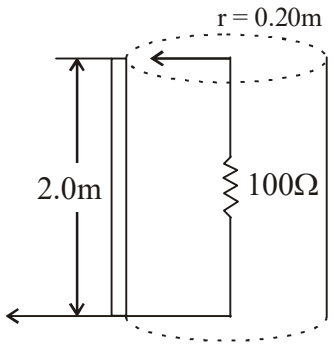
The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

1. Answer any *five* questions : 2×5=10

(a) Electric field in a region of space is given by $\vec{E} = 5x\hat{i} + 6\frac{y}{z}\hat{j} + 5z\hat{k}$, find the volume charge density and describe it physically.

(b) What is a quadrupole? Compare the potentials at large distance due to an axial quadrupole and a dipole, both are placed at the origin.

(c) The 2.0 m conductor shown in Figure rotates at 1200 rev/min in the radial field $\vec{B} = 0.1\sin\phi\hat{r}(T)$. Find the current in the closed loop with a resistance of $100\,\Omega$.



(d) Two parallel beam of electrons moving in the same direction repel each other. But two wires carrying current in the same direction attract each other. Explain.

(e) State and explain Thevenin theorem.

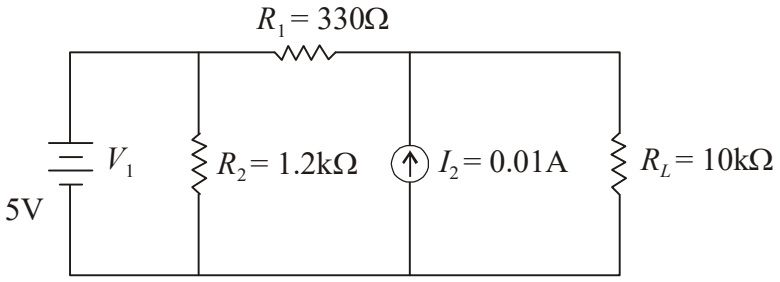
(f) Derive the differential form of Faraday's Law.

(g) Show that when a coil of inductance L and resistance R is connected in series to the source of an alternating *emf* $v = v_0 \sin wt$, the average rate of consumption of energy is $\frac{V_0^2 R}{2\left(R^2 + w^2 L^2\right)}$.

2. Answer any *three* questions : 5×3=15

(a) A solid sphere of radius R carries volume charge density given by $\rho(r) = \rho_0\left(1 - \frac{r}{R}\right)$ for $r \le R$ and $\rho(r) = 0$ for $r > R$. Find the electric field inside and outside the sphere using Gauss's Law. 5

(b) State Reciprocity theorem. Using superposition theorem find the current through R_L for the network given below.

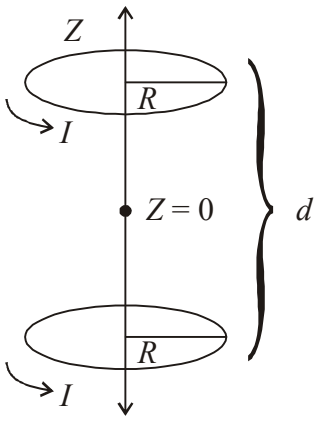


1+4

(c) (i) Determine the self-inductance of toroid with N number of uniform turns. The inner and outer radii of the toroid are r_1 and r_2, respectively. Width of the toroid is h.

(ii) Two coils with inductances L_1 and L_2 have resistances R_1 and R_2, respectively. They are connected in parallel and fed from an AC source. Determine the mutual inductance between the coils if the currents in the two coils are in phase. 2+3

(d)

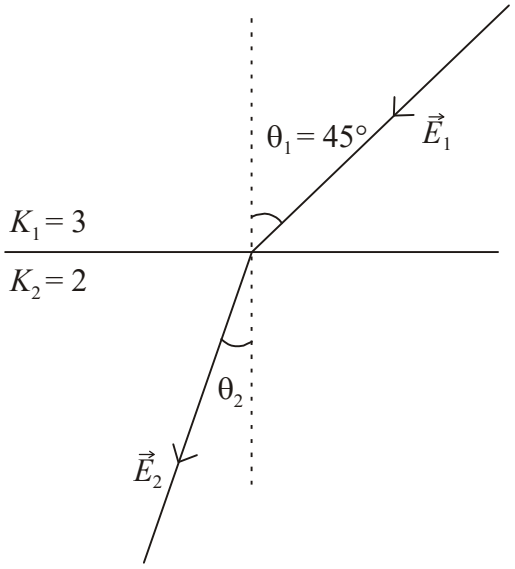


(i) We have two current carrying loop a shown in the above arrangement. They are 'd' distance apart. Find the field (B) as a function of z and show that $\frac{\partial B}{\partial z}$ is zero at the point $z = 0$.

(ii) Determine 'd' such that $\frac{\partial^2 B}{\partial z^2} = 0$ at the midpoint and find the resulting magnetic field at the center. 3+2

(e) (i) A point charge 'q' is placed at a distance 'd' from the center of a grounded conducting sphere of radius 'a' ($a < d$). Calculate the magnitude and location of the image charge.

(ii) At a plane surface between two dielectric with $K_1 = 3$ and $K_2 = 2$, electric field $E_1 = 1200$ v/m in the upper medium makes an angle $\theta_1 = 45°$ with the normal to the interface. (See figure below). Find E_2 and θ_2 for this case. 3½+1½


$\theta_1 = 45°$
$\vec{E}_1$
$K_1 = 3$
$K_2 = 2$
θ_2
$\vec{E}_2$