End Semester Examination, 2022

Semester - II

Physics

PAPER - C3T

Full Marks : 40

Time : 2 Hours

Group - A

1. *Answer any five out of eight questions :5x2=10*

a) Show that $V = xyz$ satisfy Laplace equation. 2

b) Show that electrostatic field is conservative. 2

c) The radius of a circular coil is 0.1m. Find the ratio of magnetic fields at two points 0.1m and 0.2m from the centre. 2

d) What is the difference between the torque acting on a magnetic dipole and an electric dipole ? 2

e) An electric field is represented by $\vec{E} = y\hat{i} + x\hat{j}$. Show that the potential function is $V(x,y) = -xy + c$, where c is a constant.

f) Write down the differences between Magnetization vector and Magnetic Intensity.

g) What is "displacement current" ?

h) State the Thevenin theorem.

Group - B

Answer any four out of six questions : 4x5=20

2. What is Curie-Weiss law? Define the terms hysteresis, retentivity and coercivity. 2+3

3. $\sigma = \sigma_0 \cos\theta$, surface charge density on the surface of a sphere of radius R. Find out dipole moment $\vec{P}$. 5

4. Can the following be a possible electrostatic field?
$\vec{E} = K\left[y^2 x\hat{i} + \left(2xy + z^2\right)\hat{j} + 2yz\hat{k}\right]$
Derive Poisson's equation from Gauss's law in electrostatics. 3+2

5. i) Show that the magnetic vector potential $\vec{A}$ due to uniform magnetic field $\vec{B}$ is given by
$$\vec{A} = -\frac{1}{2}\left(\vec{r} \times \vec{B}\right)$$ 2

   ii) Consider the magnetic field produced by a long straight wire carrying current I at a (perpendicular) distance R from it. Show that the length of the current that contributes 90% of the total field is given by 4.13*R*. 3

6. A sinusoidal voltage $V = V_0 \cos wt$ is applied to a series LCR circuit.

   i) Show that the instantaneous current in the circuit is given by $I = I_0 \cos(wt - \phi)$,

where $I_0 = \dfrac{V_0}{\sqrt{R^2 + \left(wL - \dfrac{1}{wC}\right)^2}}$ and $\phi = \arctan\left(\dfrac{wL - \dfrac{1}{wc}}{R}\right)$

2

   ii) Find the two half power frequencies and hence the Q-factor of the circuit. 2+1

7. i) State the maximum power transfer theorem. Prove is for a source driving a complex load. 1+3

   ii) What do you mean by "impedance matching"? 1

Group - C

Answer any one out of two questions : 1x10=10

8. a) If the maximum steady current in an LR circuit decreases to 50% in 1.5 s. Calculate the value of inductance. If $R = 5\Omega$ calculate the time constant. Explain, whether the law of conservation of energy violated due to production of back e.m.f. in L-R circuit.

   b) A magnetic dipole of moment $\vec{m} = m\hat{j}$ is placed in a magnetic field $\vec{B} = \left(x^2 - y^2\right)\hat{i} - 2xy\hat{j}$
   Show that the force on the dipole $-2m\left(y\hat{i} + x\hat{j}\right)$. 2

   c) Find the steady current density that can give rise to a magnetic field $\vec{B} = K\left(y\hat{i} - x\hat{j}\right)$
   where K is a constant. 3

9. i) Considering electrostatic energy of a charge distribution show that one can't make a point charge particle. 2

ii) Derive the boundary conditions for electric field. 3

iii) Show that the electric dipole moment of a charge distribution is independent of choice of origin if the total charge of the distribution is zero. 2

iv) Show that the mutual interaction energy of two dipoles of moments $\vec{P}_1$ and $\vec{P}_2$ is given by

$$U_{mutual} = \frac{1}{4\pi \epsilon_0}\left[\frac{\vec{P}_1.\vec{P}_2}{r^3} - \frac{3(\vec{P}_1.\vec{r})(\vec{P}_2.\vec{r})}{r^5}\right] \quad 3$$