2020

PHYSICS

[HONOURS]

Paper : V

[SUPPLEMENTARY]

Full Marks : 75 Time : 4 Hours

The figures in the right-hand margin indicate marks.

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

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

a) Find the condition, so that the vector $\vec{E} = A\left(\hat{i}ax + \hat{j}by + \hat{k}\right)$ may represent an electrostatic field.

b) Electric field in a conductor is zero— Explain.

c) What is drift velocity?

d) Write down the continuity equation involving the charge density and the current density.

e) A capacitor of $1\,\mu F$ is charged to 10,000V and then suddenly discharged through a fine wire. If all the energy went to heat the wire, how many calories of heat would be liberated adiabatically?

f) An average induced emf of 1V appears in a coil as the current in it changes from 5A in one direction to 5A in the other within 0.1s. Find the self inductance of the coil.

g) State Lenz's law.

h) For quite some time, the electric current in a circuit is given by $i = i_0 \frac{t}{T}$. Calculate r.m.s current for the period $t = 0$ to $t = T$.

2. Answer any **six** questions: 2×6=12

a) A 100V r.m.s. voltage is applied to a circuit containing 10mH inductance, $1\mu F$ condenser and 10Ω resistance in series. Calculate the frequency at which the circuit will be in resonance with the current of the same frequency.

b) Explain Earnshaw's theorem.

c) Find the electric charge on a soap-bubble having surface tension 27 dynes/cm, if air pressure inside and outside the bubble remains the same.

d) Calculate the energy in electron-volts of an electron of mass 9.1×10^{-28}gm moving with a velocity of 10^7 m/s.

e) Determine the magnetic potential arising from a point-like monopole.

f) State and Briefly explain the two laws of thermo-electricity.

g) An induction coil has mutual inductance of 5×10^{9} cgs units. If a current of 3 amp.is completely cut-off in $1/1000^{th}$ of a second, calculate the voltage induced in the secondary.

h) Find the expression for ohm's law in microscopic form.

i) Find the potential energy of an electric dipole of moment $\vec{p}$, being placed in a non-uniform electric field $\vec{E}(\vec{r})$.

j) Show that the current produced in 'n' number of cells in parallel is the same as that produced by a single cell.

3. Answer any **three** questions: $6\times3=18$

a) What is an electrical image? A point charge placed in front of an infinite grounded conducting plane. Using the method of electrical image find the density of induced charge at a point on the plane. Mention the limitation of application of the method. 1+4+1

b) i) "A charge particle cannot be held in stable equilibrium by electrostatic forces alone"— Explain with an example. 2

ii) Solve the Laplace equation using separation of variables, to find the potential in cylindrial co-ordinate system, having symmetry along the Z-axis. 4

c) i) Write down the differential equation for a series LCR circuit, driven by an alternating source of emf. Find the current and the angle of lag using complex analysis. 4

ii) A series circuit containing 10mH, a variable capacitance and a $1k\Omega$ resistance is connected to a A.C. source of 1KHz frequency. At what value of the capacitance the current flowing through the circuit is maximum? 2

d) Show that the potential due to an arbitrary charge distribution of finite extent can be expressed as the sum of multipole potentials at large distance. Explain the terms—dipole and quadrapole moments. 4+2

e) i) Find the expression for the magnetic field inside a long solenoid. 3

ii) Describe the method for the generation of uniform magnetic field in Helmholtz coil. 3

4. Answer any **four** questions: 10×4=40

a) i) Define the polarization of a dielectric material. 1

ii) Find the electric field produced by a uniformly polarized sphere of radius R. 4

iii) Suppose a charge 'q' is uniformly distributed over a cylindrical volume of radius 'R' and height 'H", centred at the origin and lying along the z-axis. Find the quadrupole moment Q_{33} of the system. 5

b) i) Set up the e.m.f. equation of a series LCR circuit driven by a sinusoidal voltage, and solve the equation to find the instantaneous current. 5

ii) With an appropriate circuit diagram, demonstrate how the frequency of a

sinusoidal voltage source may be measured by Wien bridge. 3

iii) A telephone operating at a current of 120mA has an inductance of 10H and a resistance of 100 Ω . If a 24V battery having negligible internal resistance is suddenly applied, calculate the operating time. 2

c) i) Describe the working principle of a ballistic galvanometer. What are the essential differences between a dead-beat and a ballistic Galvanometer? 5+1

ii) A 100 turn suspended-coil-Galvanometer having 4 sq.cm. area, has moment of inertia 2 gm.cm^2 and the period of vibration 20secs. Find the current sensitivity of the Galvanometer in turns of deflection measured on a scale 1 metre away per μA , if the intensity of the permanent magnetic field is 200 oersted. 4

d) i) Two equal and opposite charges are located at a certain distance apart. Sketch the electric field lines. 2

ii) A long cylinder carries a charge density 'kr', where 'k' is a constant and 'r' is the radial distance from the axis of the cylinder. Find the electric field inside the cylinder. 4

iii) Consider a point charge 'q' placed on the axis of a circular area of radius 'a', at a distance '$\frac{3}{4}a$' from the centre. Show that the total electric flux through the area is $\frac{q}{5\varepsilon_0}$, where ε_0 carries its usual meaning. 4

e) i) Explain Peltier effect and distinguish it from Joule's effect. Demonstrate Peltier effect in view of a simple experimental device. Show that Thomson effect may be predicted from thermodynamical consideration. 3+2+2

ii) Determine Peltier co-efficients, neutral temperature, inversion temperature and the total e.m.f. of a Cu-Fe thermocouple whose junctions are maintained at 0^oC and 100^oC, using the following data:

$a_{Cu\text{-}Pb} = 2.76\,\mu V/^oC$, $a_{Fe\text{-}Pb} = 16.55\,\mu V/^oC$

$b_{Cu\text{-}Pb} = 0.12\,\mu V/^oC^2$, $b_{Fe\text{-}Pb} = -0.03\,\mu V/^oC^2$

Also find the Tomson e.m.f. to make a cross check on total e.m.f. 3

f) i) What is Bohr magnetor? Derive an expression for it. 3

ii) Show that the magnetic strength of a shell formed by a closed loop is the same as the circulating current. 2

iii) Magnetic field 'B' applied perpendicular to the plane of a conducting disc having conductivity 'σ', radius 'a' and thickness 'b', changes at the rate $\frac{dB}{dt}$. Calculate the power dissipated in the disc due to the induced current. 2

iv) Draw the hysteresis loop of a ferromagnetic material and calculate the heat loss of the material undergoing a cycle of magnetization. 3

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