WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 2nd Semester Examination, 2019

PHSACOR03T-PHYSICS (CC3)

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Answer Question No. 1 and any *two* questions from the rest

1. Answer any ***ten*** questions from the following: 2×10 = 20

(a) Show that $\delta(ax) = \delta(x)/|a|$, where, δ denotes the Dirac delta function.

(b) The electrostatic field at every point in a given region of space is along x axis. Show that Electric field is independent of y and z in that region.

(c) Can $\vec{E} = k[xy\hat{i} + 2yz\,\hat{j} + 3xz\,\hat{k}]$ represents an electrostatic field?

(d) Establish Poisson's equation from Gauss' law.

(e) The interior of a circular cylinder $x^2 + y^2 = R^2$ is occupied by a polarized material with the polarization $\mathbf{P} = (ax^2 + b + cy + a)x\hat{i} + px\,\hat{j}$. Find the volume and surface polarization charge densities.

(f) State the boundary conditions at the surface of separation of two dielectric media of dielectric constants ε_1 and ε_2.

(g) Show that the dipole moment is independent of the choice of origin if the total charge of the distribution is zero.

(h) For a uniform magnetic induction $\vec{B}$, check the possibility of a vector potential given by $\vec{A} = \frac{1}{2}(\vec{B} \times \vec{r})$.

(i) Sketch graphically how the current grows with time in a series R-L circuit.

(j) State Norton's theorem for electric circuits.

(k) A single turn loop is situated in air, with a uniform magnetic field normal to its plane. The area of the loop is 5 meter^2. What is the emf appearing at the terminals of the loop if the rate of change of flux density is 2 webers/meter^2/sec?

(l) What is sharpness of resonance? How is it related to the Q factor?

(m) In the interior of a permanent magnet **H** and **B** fields are opposite to each other. Which part of the Hysteresis loop corresponds to such magnetic state.

(n) A long solenoid of length L, carrying current I, is moving with uniform velocity v, towards a ring of radius a, slightly larger than that of the solenoid so that it can pass through the ring. Graph the emf induced in the ring as a function of time.

2. (a) Using Gauss' law find the electric field at a distance z from a straight infinite line charge of uniform charge density. Calculate the potential at that point. 2+1

(b) A static charge distribution produces a radial electric field 3+2

$$\vec{E} = A\frac{e^{-br}}{r}\hat{e}_r$$

where A and b are constants. Find the charge density ρ and the total charge Q over all space.

(c) Consider an assembly of n fixed point charges $q_1, q_2, \ldots\ldots, q_n$ in vacuum. For simplicity, assume $q_i > 0$ for all i. Let $\vec{E}(\vec{x})$ be the electric field produced by these charges. Can we find a point $\vec{X}$ in space such that a test charge Q placed there will be in stable equilibrium? 2

3. (a) Using Biot-Savart law (for volume distribution of current), show that magnetic field is *Solenoidal*. 3

(b) Find the magnetic field at a distance z along the axis of a circular ring of radius a carrying current I. If a very small circular loop of radius r ($r << a$) is placed at a distance z on the axis making an angle θ with the larger ring, find the mutual inductance of this system. 3+1

(c) Consider a magnetized material with magnetization $\vec{M}$. Show that the magnetic vector potential is equivalent to that produced by a volume current $\vec{J} = \vec{\nabla} \times \vec{M}$ and a surface current $\vec{K} = \vec{M} \times \vec{n}$. 3

4. (a) A thin circular ring of radius 'a' has a uniform line charge of density λ on it. Calculate the field and potential at a point P on the axis of the ring at a distance z from its plane. Where is $E(z)$ maximum? 2

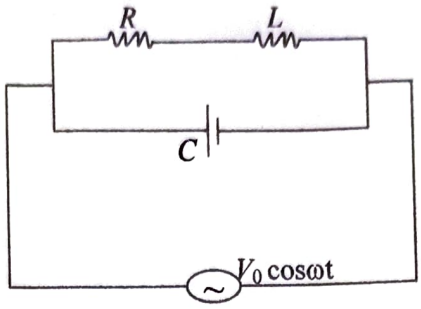
(b) Show that the energy of a dipole in an electric field is given by $U = -\vec{p}.\vec{E}$. 2

(c) A charge $+q$ is placed in front of an earthed infinite conducting plane. Show that the net charge induced on the plane is $-q$. 3

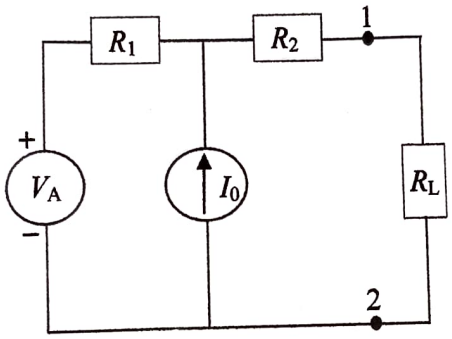
(d) Show that the electric field produced by a uniformly polarized sphere outside it is same as that of a point dipole at the origin with dipole moment equal to the net dipole moment of the sphere. 3

5. (a) What are the characteristics of a constant current source and a constant voltage source? 2

(b) A parallel LCR circuit is shown in figure. Find the resonant frequency. Show that the impedence of the circuit at resonance is equal to L/CR. 4



(c) In the circuit (shown in the figure) $V_A = 4\,\text{V}$, ideal current source with current $I_0 = 2\text{A}$, $R_1 = 2\,\Omega$ and $R_2 = 3\,\Omega$. Find the Thevnin equivalent voltage V_{TH} and the resistance, R_{TH} for the network to the left of terminals 1 and 2. 1+2+1



What would be the maximum power delivered to the resistance R_L?

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