WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 2nd Semester Supplementary Examination, 2021

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 $\delta(x)$ is Dirac delta function.

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

(c) Find the charge density that produce the electric field in V/m, $\vec{E} = 10\sin\theta\hat{\mathbf{r}} + 2\cos\theta\hat{\boldsymbol{\theta}}$ is expressed in polar co-ordinate.

(d) A cylindrical surface of length *l* and radius *r* is placed in a uniform electric field of magnitude *E*. Find the total flux Φ through the surface of the cylinder assuming that the axis of the cylinder is parallel with the direction of the electric field.

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

(f) When a neutral dielectric is polarized, the polarization volume charges and surface charges arise. Show that the total charge remains zero.

(g) Show that Kirchhoff's 1st and 2nd law are consistent with conservation of charge and energy respectively.

(h) Express Ohms law in differential form. Show that for steady flow through homogeneous material, $\vec{\nabla}\cdot\vec{E} = 0$.

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

(j) Show that the reactance of series L-C-R circuit is inductive when the AC source frequency is greater than the resonance frequency.

(k) A magnetic field $B = \hat{i} + 2\hat{j} - 4\hat{k}$ T and an unknown electric field *E* exists in a region. If an electron moving within region with velocity $v = 6\hat{i} + 2\hat{j} - 4\hat{k}$ m/s experiences no force. Find *E*.

(l) 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?

(m) Find the r.m.s. value of the current given by $i = i_0\cos(\omega t + \theta)$.

(n) Derive the relation between the normal components of the displacement field vector between two points in the opposite side but in the immediate neighbourhood of the interface of two dielectrics of dielectric constants ε_1 and ε_2 containing a surface charge density σ.

2. (a) State Gauss's law in electrostatics. Express this law in differential form. 1+2

(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*, in the entire space.

(c) Consider an assembly of *n* fixed point charges $q_1, q_2, ..., q_n$ 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

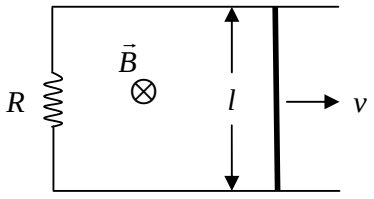
3. (a) Using Biot-Savart law (for volume distribution of current), show that magnetic field is Solenoidal. 3

(b) Starting from Ampere's law $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$, show that for a magnetized material the integral form of Ampere's law takes the form $\oint \vec{H}.\vec{dl} = I_f$ where I_f is the total free current passing through Amperian loop and $\vec{H} = \frac{\vec{B}}{\mu_0} - \vec{M}$. 3

(c) A metal bar of mass *m* slides frictionlessly on two parallel conducting rails a distance *l* apart as shown in figure below. A resistor *R* is connected across the rails and a uniform magnetic field $\vec{B}$ pointing into the page fills the entire region. 2+2

(i) If the bar moves to the right at a speed *v* what is the current in the resistor?

(ii) If the bar starts moving at time $t = 0$ with speed v_0 find the speed at a later time *t*.



Figure

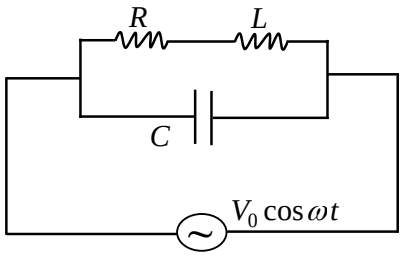
4. (a) A variable condenser of capacitance *C* and a resistance *R* are in series with an AC source of angular frequency ω. The voltage-drop across *R* is *V*. When the capacitance is changed to *KC*, the voltage-drop across *R* is doubled. Calculate *K* in terms of *R*, *C* and ω. 3

(b) A spherical condenser consists of two concentric conducting spheres of radii *a* and *b* (*a* > *b*). The outer sphere is grounded and a charge *Q* is placed on the inner sphere. Find the electrostatic energy of the system. Now, the outer conductor contracts slowly from radius *a* to radius a'. Find the work done by the electric force. 2+1

(c) A 80 volt DC source is switched on to a circuit containing a resistor, $R = 5\ \Omega$ in series with an inductor, $L = 20$ mH. Calculate the time when the current attains a value of 6 A. Derive the formula you use. 1+3

5. (a) Self inductance of two coils are L_1 and L_2 and their mutual inductance is M. Starting from their energy conservation show that $M^2 \leq L_1 L_2$. What is coefficient of coupling and what is its maximum value? 3+2+1

(b) A parallel LCR circuit is shown in figure. Find the resonant frequency. Show that the impedance of the circuit at resonance is equal to L/CR. 3+1



N.B. : *Students have to complete submission of their Answer Scripts through E-mail / Whatsapp to their own respective colleges on the same day / date of examination within* 1 *hour after end of exam. University / College authorities will not be held responsible for wrong submission (at in proper address). Students are strongly advised not to submit multiple copies of the same answer script.*

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