WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 2nd Semester 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) Suppose the electric field in some region is found to be $\vec{E} = kr^3\hat{r}$, in spherical polar coordinates (k is some constant). Find the charge density $\rho(r)$.

(b) Establish the relation

$$\vec{p} = \varepsilon_0(K-1)\vec{E}.$$

Hence prove that polarization vanishes in vacuum.

(c) Find the r.m.s value of the ac voltage represented by

$$e(t) = \begin{cases} e_0 \cos\left(\omega t + \dfrac{\pi}{2}\right) & \text{for } 0 \le \omega t \le \pi \\ 0 & \text{for } \pi \le \omega t \le 2\pi \end{cases}$$

(d) Show that the dimension of ϵ/σ is the dimension of time. Where ϵ and σ denote the permittivity and conductivity of the medium respectively.

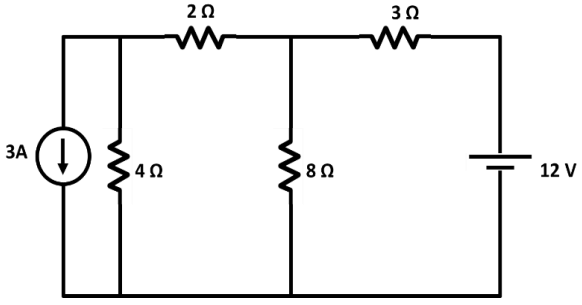
(e) Why a parallel LC circuit is inductive but a series LC circuit is capacitive at resonant frequency?

(f) Magnetic field arises due to charges in motion. Can a system have magnetic moment even though its net charge is zero? Give example.

(g) A pure dipole p is situated at the origin in the Z direction. What is the force on a point charge q at (a, 0, 0) (Cartesian Co-ordinate) due to the dipole?

(h) A point charge q is placed at a distance d from an infinite conducting plane. Find the work necessary to move the charge to infinite distance from the plane.

(i) Using the rule of transformation from a constant current source to a constant voltage source or vice versa, find the voltage across the 8Ω resistance ($V_{8\Omega}$) in the network given below:



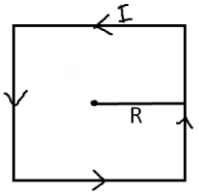
(j) Explain why the electric field inside a hollow spherical charge distribution is zero.

(k) Determine the effect when an electric dipole is placed in a homogenous electric field and a non homogeneous electric field.

(l) In a certain region of space electric field is given by $\vec{E} = \hat{j}E_0 \cos(\omega t - kx)$. Using the differential form of Faraday's law find the corresponding magnetic field $\vec{B}$.

(m) Calculate the magnetic dipole moment due to the orbital motion of an electron.

(n) Find the magnetic field at the center of a square loop that carries a steady current *I*. Let *R* be the distance from the center to the side as shown in the figure.



2. (a) Using Coulomb's law of electrostatics and the principle of superposition of electric field, prove that the electric field generated by any static charge distribution obeys the relation 2

$$\vec{\nabla} \times \vec{E} = 0$$

(b) An electron of charge *e* and mass *m* is released on the axis of a large circular loop of wire carrying uniform distribution of positive charge *Q*. Assuming that the electron starts a short distance away from the centre of the loop, show that it will execute a S.H.M. with angular frequency 3

$$\omega = \left[\frac{eQ}{4\pi\varepsilon_0 m r^3} \right]^{1/2}$$

(c) Find the potential inside a uniformly charged solid sphere of radius *R* and charge *q*. 3

(d) Find the electrostatic energy stored in a uniformly charged solid sphere of radius *R* and charge *q*. 2

3. (a) Establish Gauss's law in Dielectric and hence define Electric Displacement (D). Can we write $\vec{\nabla} \times \vec{D} = 0$ like $\vec{\nabla} \times \vec{E} = 0$? Explain. 2+1+1

(b) A sphere of radius *R* carries a polarization $\vec{P}(r) = k\vec{r}$ where *k* is a constant and $\vec{r}$ is the vector from the centre.

(i) Calculate the bound charge densities σ_b on the surface and ρ_b. (1+1)

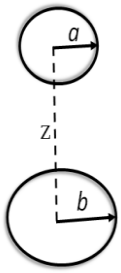
(ii) Find the electric field inside and outside the sphere. 2+2

4. A small loop of wire (radius *a)* is held at a distance *z* above the center of a large loop (radius *b*) as shown in figure below. The planes of the two loops are parallel and perpendicular to the common axis.

(i) Suppose current *I* flows in the large loop. Find the flux through the small loop. (The small loop is so small that you may consider the field of the large loop to be essentially constant). 3

(ii) Suppose current I flows in the small loop. Find the flux through the large loop. (The small loop is so small that you may treat it as a magnetic dipole.) 3

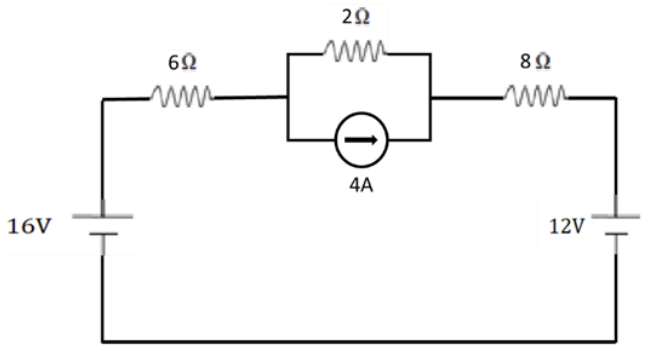
(iii) Find the mutual inductances and confirm that $M_{12} = M_{21}$ 3+1



5. (a) "Ampere circuital law is bound to fail for non steady currents" – Justify the statement. 2

(b) A 100V, 100W lamp is operated at 200V, 50Hz mains. What (i) pure resistance, (ii) ideal inductance to be connected in series to get normal glow of the lamp? Why is 220V *ac* more dangerous than 220 V *dc*? 3+1

(c) Using Thevenin's theorem, find the current through 8Ω resistance in the following network. 4



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.*

———×———