B.Sc. 2nd Semester (Honours) Examination, 2020-21

PHYSICS

Course ID: 22411 **Course Code: SH/PHS/201/C-3**

Course Title: Electricity and Magnetism

Time: 1Hour 15 Minutes **Full Marks: 25**

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words
As far as practicable

Section-I

1. Answer any ***five*** questions. $1\times 5 = 5$

(a) A regular tetrahedron consisting of a charge of +Q C at its centroid. Find the flux of electric field through any one of its face.

(b) State the Gauss's law in magnetostatics mentioning its significance.

(c) Show that the potential distribution within a conducting medium satisfies Laplace's equation as long as the medium is homogeneous and the current distribution is time invariant or steady.

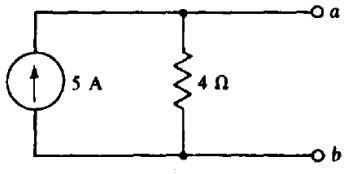
(d) What do you mean by conservative field?

(e) Define electric susceptibility.

(f) What is the significance of the area of a B-H loop?

(g) When an ordinary 'current source' can be renamed as 'constant current source'?

(h) Transform the following current source into a voltage source.



Section-II

2. Answer any ***two*** questions: $5\times 2 = 10$

(a) (i) Using Gauss's law, find electric field inside a parallel plate air filled capacitor (taking +σ and –σ as the existing surface charge densities on the two plates respectively.

(ii) Write down the differential form of Gauss's law. Suppose that electric field in some region is found to be $\vec{E} = \alpha r^3 \hat{r}$ V/m in spherical coordinates (α is a constant). Find the electric charge density in the region. [2+(1+2)]

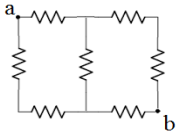
(b) (i) Write down the defining equation of fundamental magnetic field and mention the significance.

(ii) From Biot-Savart's law show that $\vec{\nabla}\cdot\vec{B} = 0$. P.T.O

(iii) Find energy magnetic field at the centre of a regular hexagonal loop of side *a* carrying current *I*.

[1+2+2]

(c) (i) Find the equivalent resistance between point *a* and *b* for the following resistance configuration where resistance of each resistor is 10 ohm.



(ii) Find the vector electric field at (1,1,1) due to the charges +1C(1,0,0), +1C(0,1,0) and +1C(0,0,1)

[3+2]

(d) (i) Find capacitance of a Spherical capacitor of shell radii *a* and *b* respectively (*a*< *b*). Hence find the capacitance of an isolated sphere.

(ii) Show that $\vec{\nabla}\times\vec{E}=-\partial\vec{B}/\partial t$ in time varying era and mentioning the laws associated with it.

[3+2]

Section-III

3. Answer any ***one*** question: $10\times1=10$

(a) (i) Find $\vec{B}$ at a point on the axis of an infinitely long air-core solenoid carrying current *I* with no. of turns per unit length being *n*. What will be the magnetic field at the end of such solenoid?

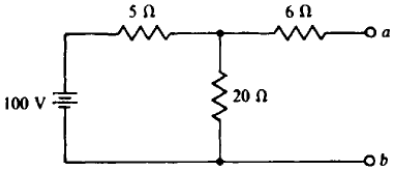
(ii) Show that the electric field due to an electric dipole at a far away field point can be expressed as: $\vec{E}=\frac{1}{4\pi\varepsilon}\left[\frac{3(\vec{p}\cdot\vec{r})\vec{r}}{r^5}-\frac{\vec{p}}{r^3}\right]$; where symbols have their usual meanings. [(4+1)+5]

(b) (i) Prove that dielectric displacement vector $\vec{D}$ can be related to total Electric field ($\vec{E}$)and Polariaztion vector as: $\vec{D}=\varepsilon_0\vec{E}+\vec{P}$. Hence show that $\varepsilon_r=1+\chi_e$.(symbols have their usual meanings)

(ii) The permittivity of the dielectric material between the plates of a parallel-plate capacitor (inter-plate separation *d* and plate area *A*) varies uniformly from ε_1 to ε_2 from one plate to another. Show that the capacitance of the capacitor (*C*) can be expressed as:

$$C=\frac{A}{d}\frac{(\varepsilon_2-\varepsilon_1)}{\ln(\varepsilon_2/\varepsilon_1)}$$

(iii) Find the resistance of the resistor which draws a current of 5A when connected across *a* and *b* of the circuit below.



[(3+1)+3+3]