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B. Sc. Course (CBCS) Ordinance Sem-VI

EXAMINATION MAY 2023

Physics - Electromagnetic Theory II & Theory of Relativity

[Time: 2 Hours]

[Max. Marks:80]

- Instructions:**
- 1) All questions are **compulsory**.
 - 2) Figures to the **right** indicate **full** marks.
 - 3) Symbols have their **usual** meaning, unless otherwise stated.
 - 4) Draw illustrated diagrams **wherever** necessary.
 - 5) Use of log tables and non-programmable calculators is allowed.

Constants:

Velocity of light in air $= c = 3 \times 10^{10} \text{ cm/s}$,

Permeability of free space $= \mu_0 = 4\pi \times 10^{-7} \text{ MKS units}$,

Planck's constant $h = 6.63 \times 10^{-34} \text{ J-s}$.

Q1 Answer **any four** of the following:

4x4=16

- a) i) State the law which gives magnetic field due to steady current.
ii) A long wire carries a current of 5A. Find the magnetic field at a distance of 1 m from the wire.
- b) i) Define the term magnetization.
ii) The measured magnetic dipole moment per atom of iron is $20.6 \times 10^{-24} \text{ Am}^2$ and number density of iron atoms is given as $8.5 \times 10^{28} \text{ m}^{-3}$. Calculate the magnetization of iron, assuming perfect alignment of all atomic dipole moment.
- c) Which materials are called as linear magnetic materials? How they are classified depending upon their susceptibility?
- d) Write the set of Maxwell's equations for time varying fields and give physical significance of each equation.
- e) Due to Doppler effect, an astronaut travelling in space sees a red emitting light of frequency $\nu_0 = 4.8 \times 10^{14} \text{ Hz}$. as a green star of frequency $\nu = 5.6 \times 10^{14} \text{ Hz}$. Find the speed of the astronaut relative to the star.

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4x4=16

Q2 Answer any four of the following:

a) For a magnetized material show that,

$$\nabla \times \vec{H} = \vec{J}$$

b) What is spontaneous magnetization? Define Curie temperature.

c) The parallel pole faces of a magnet have an area of 10 cm^2 each and they are 4 cm apart. Given that the magnetic induction between them is 0.05T, calculate the magnetic field energy in the volume between them.

d) What are ferrites? Give schematic representation of atomic spins in ordered spin structures for

- i) Ferromagnetic
- ii) Anti-ferromagnetic
- iii) Ferrimagnetic

e) Two electrons leave a radioactive sample in opposite direction, each having a speed of $0.67c$ relative to sample. Find the velocity of one electron relative to the other electron.

f) Explain the concept of inertial frame of reference. State two postulates of Special Theory of Relativity

Q3 A) State Biot Savart's law and using this law find the magnetic field B due to a circular coil carrying current I at a point on the axis of the coil. 06

OR

A) What is magnetic vector potential? Obtain its expression as a function of current density \vec{J} 06

B) Taking $\vec{A} = \frac{\mu_0}{4\pi} \int_{V_0} \vec{M}(\vec{r}') \times \frac{(\vec{r} - \vec{r}')}{|\vec{r} - \vec{r}'|^3} dv'$, show that, 06

$$\vec{B}(\vec{r}) = -\mu_0 \nabla \varphi^*(\vec{r}) + \mu_0 \vec{M}(\vec{r})$$

Q4 A) Derive B-H relationship for magnetic circuits containing permanent magnets. 06

OR

A) Discuss the origin of Paramagnetism. Obtain an expression for paramagnetic susceptibility. 06

B) Show that when a ferromagnetic material undergoes a cycle of magnetization the energy loss per cycle is proportional to the area enclosed by the B-H loop. 06

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- Q5 A) State Faraday's law of electromagnetic induction. Obtain an expression for the same in differential form. **06**
- OR**
- A) Derive Galilean transformation equations. Show that the Newton's laws of motion are invariant under Galilean transformations. **06**
- B) Using Lorentz transformation equations derive relativistic equations for Doppler effect in light. **06**
- Q6 A) i) Using Lorentz transformation equations deduce the expression for length contraction. **03**
- ii) A particle with proper life time of 2×10^{-6} s moves in a laboratory with a speed $0.9c$. Calculate its life time as measured in the laboratory. **03**
- OR**
- A) What is Twin Paradox? Explain the resolution of Twin Paradox. **06**
- B) Derive the relation which gives equivalence of mass and energy **06**