CARMEL COLLEGE OF ARTS, SCIENCE & COMMERCE FOR WOMEN, NUVEM-GOA

SEMESTER END EXAMINATION, JUNE 2022

Semester: VI **Subject:** Physics

Electromagnetic Theory – II and Theory of Relativity (PYC 110)

Total Marks: 80 **Date:** 10/06/2022 **Duration:** 2 hours **Total Number of Pages:** 03

Instructions:

1) *All questions are compulsory, however internal choice is available.*
2) *Figures to the right indicate maximum marks to the question.*
3) *Symbols have their usual meanings unless otherwise stated.*
4) *Draw neat diagram wherever necessary.*
5) *Use of non-programmable calculator is permitted.*
   Constants: $\boldsymbol{c = 3 \times 10^8 m/s}$ ***and*** $\boldsymbol{\mu_0 = 4\pi \times 10^{-7} Ns^2/C^2}$.

Q1. Answer **any four** of the following questions***:*** ***(4x4=16)***

a) What do you mean by magnetic scalar potential? Write an expression for it in terms of magnetic dipole moment $\vec{m}$.

b) Using Biot Savart's law find the magnetic field $\vec{B}$ due to a long wire carrying a steady current 'I'.

c) Comment on conventional current and atomic current. Hence, define magnetization of current density.

d) Write the mathematical equation for that the magnetic dipole field of a distant circuit. Also, define magnetic dipole moment.

e) Give schematic representation of atomic spins for the following materials

(i) Ferromagnetic (ii) Antiferromagnetic

(iii) Paramagnetic (iv) Ferrimagnetic

f) For magnetic circuit containing permanent magnets, establish the relation between B and H, using Ampere's circuital law.

Q 2. Answer **any four** of the following questions: **(*4*x*4 = 16*)**

a) Show that the energy loss due to hysteresis is $W = \oint H\, dB$, where $W \rightarrow$ work done by the field, $H \rightarrow$ magnetization field.

b) Derive an expression the energy density for a long solenoid in terms of it's magnetic induction (B).

c) Write the set of Maxwell's equation for time varying fields and give the physical significance of each.

d) State the Poynting theorem. Write the expression for Poynting vector.

e) A long solenoid has *n* turns per unit length. A ring of wire of radius *r* is placed within the solenoid, perpendicular to the axis. What is the mutual inductance?

f) Two electrons leave a radioactive sample in opposite directions with a speed of 0.6c with respect to the sample. What is the speed of one electron relative to the other according to Newtonian mechanics? What is the relativistic result?

Q3.

A)

i) An iron ring 15 cm in diameter and 10 cm^2 in area is wound with 200 turns of wire. Determine the reluctance in the coil, if the flux density through the coil is 1Wb/m^2 and relative permeability of iron is 500. **(3)**

ii) Find the magnetization of the bar magnet of length 5cm and cross-sectional area 2 cm^2. The magnetic moment of the magnet is 1 Am^2. **(3)**

OR

A) With the help of a neat diagram, explain the construction and working of Helmholtz coil. Also give it's applications. **(6)**

B) Deduce boundary conditions to be satisfied by the magnetic field vectors $\vec{B}$ *and* $\vec{H}$ at the interface of two media. **(6)**

Q4.

A)

i) How much energy is stored in a 5.0 H inductor carrying 35 A? **(3)**

ii) The susceptibility of a paramagnetic material at 300 K is 1.8×10^{-5}. At what temperature will the susceptibility increase to 2×10^{-5} ? **(3)**

OR

A) Write the general formula for magnetic energy of coupled circuits. Using the same, find the magnetic energy of the system of two circuits of self-inductances L_1 and L_2 which are coupled by a mutual inductance M. Also, show that $L_1 L_2 \geq M$. **(6)**

B) Show that the molecular field inside a material is $\vec{H} = \vec{H}_0 + \frac{1}{3}\vec{M}$, where $\vec{H}_0$ →macroscopic magnetic intensity of the material and $\vec{M}$ →magnetizaton of the sample. **(6)**

Q5. A)

i) Define inertial and non-inertial frame. Is a reference frame moving with constant speed w.r.t. an inertial frame also inertial? Explain **(3)**

ii) What was the problem with Galilean Transformation? How did Einstein resolve it? **(3)**

OR

A) State Faraday's law of electromagnetic induction. Derive an expression for the same in differential form. **(6)**

B) Discuss the Michelson Morley experiment with the help of a neat schematic diagram. Also, comment on the result. **(6)**

Q6.

A)

i) A meterstick is moving by an observer in a direction parallel to its length. The speed of the meterstick is 0.50c. What is its measured length in the reference frame of the observer? **(3)**

ii) If a moving clock is to have a time-dilation factor of 10, what must be its speed? **(3)**

OR

A) Show that Lorentz transformation equations reduce to Galilean transformation when $v \ll c$, where v → velocity of the moving reference frame and c → speed of light. **(6)**

B) Derive Einstein's relativistic velocity addition equation using Lorentz transformation equations. **(6)**
