MPH-007

ASSIGNMENT BOOKLET

M.Sc. (Physics) Programme
(MSCPH)

CLASSICAL ELECTRODYNAMICS

Valid from 1st JANUARY, 2024 to 31st December, 2024

School of Sciences
Indira Gandhi National Open University
Maidan Garhi, New Delhi-110068
(2024)

Dear Student,

Please read the section on assignments in the Programme Guide for M.Sc. (Physics). A weightage of 30 per cent, as you are aware, has been earmarked for continuous evaluation, **which would consist of one tutor-marked assignment** for this course. The assignment is in this booklet. The total marks for this assignment is 100, of which 40 marks are needed to pass it.

Instructions for Formatting Your Assignments

Before attempting the assignment please read the following instructions carefully:

1) On top of the first page of your answer sheet, please write the details exactly in the following format:

ENROLMENT NO.: ……

NAME: ……

ADDRESS: ……

COURSE CODE:…….

COURSE TITLE: ……

ASSIGNMENT CODE: ……..

STUDY CENTRE: …….. **DATE:** …….

PLEASE FOLLOW THE ABOVE FORMAT STRICTLY TO FACILITATE EVALUATION AND TO AVOID DELAY.

2) Use only foolscap size writing paper (but not of very thin variety) for writing your answers.

3) Leave 4 cm margin on the left, top and bottom of your answer sheet.

4) Your answers should be precise.

5) **Submit the complete assignment answer sheets containing Part A and Part B, within the due date.**

6) The assignment answer sheets are to be submitted to your Study Centre as per the schedule. **Answer sheets received after the due date shall not be accepted. We strongly suggest that you retain a copy of your answer sheets.**

7) This assignment is **valid from 1st January, 2024 to 31st December, 2024**. If you have failed in this assignment or fail to submit it till its validity, then you need to get the assignment for the next year and submit it as per the instructions given in the Programme Guide.

8) For any queries, please contact: srjha@ignou.ac.in

We wish you good luck.

Tutor Marked Assignment
CLASSICAL ELECTRODYNAMICS

Course Code: MPH-007
Assignment Code: MPH-007/TMA/2024
Max. Marks: 100

Note: Attempt all questions. The marks for each question are indicated against it.

PART A

1. a) Write Maxwell's equations in differential and integral forms. How are these equations modified in vacuum (charge and current free region)? Explain how Maxwell modified Ampere's law and proposed generalised Ampere's law consistent with equation of continuity and obtain the expression for the generalised Ampere's law in differential form. (10)

   b) Derive expressions for electric and magnetic fields in terms of scalar and vector potentials using the homogeneous Maxwell's equations. Show that the potentials associated with a given magnetic field are not unique. Express the inhomogeneous Maxwell's equations in terms of scalar and vector potentials. (10)

   c) (i) State Lorentz force law for the motion of a charged particle in electromagnetic field.

   (ii) Using this law, show that in a uniform static magnetic field, a charged particle having velocity perpendicular to the magnetic field will move on a circular path.

   (iii) If the magnetic field is in the *z*-direction, write the *x*- and *y*-components of the equation of motion for the force law obtained in part (ii) above.

   (iv) Uncouple the equations obtained in part (iii) and show that v_x satisfies a harmonic oscillator equation. (2+2+3+3)

2. a) Using driven harmonic oscillator model, derive an expression for AC electric susceptibility in a dielectric made of non-polar atoms/molecules. (10)

   b) Write Maxwell's equations in dielectric material medium. Show that the homogeneous Maxwell's equations remain unchanged for a dielectric compared to its form in vacuum. (10)

PART B

3. a) Using Maxwell's equations, show that electric field satisfy the three-dimensional wave equation and hence obtain an expression for the speed of the electromagnetic waves. (5)

   b) Using the boundary conditions at the interface of two dielectrics, derive the laws of reflection and refraction in geometrical optics. (10)

c) Shown that Maxwell's equations in electrodynamics imply the existence of a vector potential and a scalar potential which satisfy inhomogeneous wave equations in which the inhomogeneous source terms are proportional to the charge density and the current density respectively. Write the solutions of these wave equations and compare them with the expressions for scalar and vector potentials for electrostatics and magnetostatics, respectively. (10)

4. a) Using the expressions for retarded scalar and vector potentials

$$\phi(\vec{r},t) = \frac{1}{4\pi\varepsilon_0}\int \frac{\rho(\vec{r},t_r)}{R}\, d\tau'$$

$$\vec{A}(\vec{r},t) = \frac{\mu_0}{4\pi}\int \frac{\vec{j}(\vec{r}',t_r)}{R}\, d\tau'$$

Obtain the expressions for electric and magnetic fields. Show that, in the static case, these expressions reduce to Coulomb's law and Biot-Savart law, respectively. (10)

b) State and explain Einstein's postulates of special theory of relativity and derive the Lorentz transformation equations. (5)

c) (i) What is Minkowski space? Show that the invariant interval plays the role of distance in Minkowski space. (5)

(ii) Show that the wave equation for a scalar function of the coordinates $\phi(\vec{r},t)$ retains its form under a Lorentz transformation. Does the same hold true for a vector function? (5)

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