MPH-007

ASSIGNMENT BOOKLET

M.Sc. (Physics) Programme
(MSCPH)

CLASSICAL ELECTRODYNAMICS

Valid from 1st JANUARY, 2025 to 31st December, 2025

School of Sciences
Indira Gandhi National Open University
Maidan Garhi, New Delhi-110068
(2025)

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, 2025 to 31st December, 2025**. 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/2025
Max. Marks: 100

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

PART A

1. a) A circular wire loop of radius *r* is kept in the *x*-*y* plane in a region of uniform magnetic field pointing in the *z*-direction. The magnitude of the magnetic field is held constant at $B = 0$ from time $t = 0$ to time $t = t_1$. Thereafter, the magnetic field is increased at constant rate from $B = 0$ at time $t = t_1$ to $B = B_0$ till time $t = t_2$ and then reduced at a constant rate from $B = B_0$ to $B = 0$ at time $t = t_3$. a) Compute the magnetic flux through the circular wire loop as a function of time. b) Compute the induced emf in the circular loop as a function of time. c) Plot the magnetic flux and induced emf as a function of time. (3+3+4)

   b) Explain the concept of displacement current. An infinitely long perfectly conducting cylindrical wire of radius *a* is surrounded by a coaxial perfectly conducting cylindrical tube of radius *b*. The potential difference between the wire and the tube is $V(t)$. Compute $\vec{\nabla} \times \vec{B}$ in the region between the wire and the tube. (5+5)

   c) (i) Obtain expressions for electric and magnetic fields in terms of scalar and vector potentials using homogeneous Maxwell's equations. (5)

   (ii) Obtain the expressions for inhomogeneous Maxwell's equations in terms of scalar and vector potentials. (5)

2. a) At time $t = 0$, a particle having charge *q* is placed at rest at the point (0, 0) in a region of crossed uniform static electric and magnetic fields specified by $\vec{E} = E\hat{y}, E > 0$ and $\vec{B} = B\hat{z}, B > 0$. Describe the motion of the particle and show that the motion is periodic. (10)

   b) Using Maxwell's equations, obtain the boundary conditions for $\vec{D}, \vec{E}, \vec{B}, \text{and} \vec{H}$ at the interface of two dielectric media. (10)

PART B

3. a) Using Fourier integral theorem, obtain the expression for the velocity of a wave packet in a medium for which the dispersion relation is given as $\omega = \omega(k)$. (10)

   b) A plane electromagnetic wave propagating in *z*-direction is incident on the boundary between two linear dielectric media. The boundary is in the *x*-*y* plane perpendicular to the direction of propagation of the wave. Using the boundary conditions on the electric and magnetic fields associated with the wave, show that if the incident wave is plane polarised then the reflected and transmitted waves also have the same polarisation. (10)

c) Show that the retarded scalar potential given by

$$\phi(\vec{r},t)=\frac{1}{4\pi\varepsilon_0}\int\frac{1}{|\vec{r}-\vec{r}'|}\rho\left(\vec{r}',t-\frac{|\vec{r}-\vec{r}'|}{c}\right)dV'$$

and the retarded vector potential given by

$$\vec{A}(\vec{r},t)=\frac{\mu_0}{4\pi}\int\frac{1}{|\vec{r}-\vec{r}'|}\vec{j}\left(\vec{r}',t-\frac{|\vec{r}-\vec{r}'|}{c}\right)dV'$$

satisfy the Lorentz gauge condition. (10)

4. a) Obtain the expressions for scalar and vector potentials due to an oscillating electric dipole at a point located at large distance from the dipole. (10)

b) Explain the phenomenon of time dilation and obtain expression relating the time intervals between two event observed by different inertial observers. (5)

c) A charged particle is moving with relativistic speed in a static, uniform electric field $\vec{E}=(E,0,0)$ along the x-axis. Assume that the particle is initially at rest so that the motion is effectively one-dimensional. Express the energy of the particle as a function of instantaneous position $x(t)$ and solve the resulting equation of motion to obtain the value of $x(t)$. (5)

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