Assignment Booklet

M.Sc. (Physics) Programme
(MSCPH)

MATHEMATICAL METHODS IN PHYSICS

Valid from 1ˢᵗ January, 2026 to 31ˢᵗ December, 2026

ignou
THE PEOPLE'S
UNIVERSITY

School of Sciences
Indira Gandhi National Open University
Maidan Garhi, New Delhi-110068
(2026)

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 assignment answer sheets 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, 2026 to 31st December, 2026**. If you have failed in this assignment or fail to submit it by December 31, 2026, then you need to get the assignment for the year 2027, and submit it as per the instructions given in the Programme Guide.

8) **You cannot fill the examination form for this course** until you have submitted this assignment. For any queries, please contact: drsgupta@ignou.ac.in; slamba@ignou.ac.in

We wish you good luck.

Tutor Marked Assignment
MATHEMATICAL METHODS IN PHYSICS

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

PART A

1. a) Reduce the following PDE into three ODEs:

$$\left[\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}\right]f(x,y,z) + k^2 f(x,y,z) = 0$$
(5)

   b) Derive an integral equation corresponding to the ODE:
$$y'' - 2y = 0$$
   subject to the conditions: $y(0) = 4;\ y'(0) = -2$
(5)

   c) Use the method of separation of variables to reduce the Laplace's equation
   $\nabla^2 f = 0$ into three ODEs.
(5)

   d) Using the generating function for Bessel functions of the first kind and integral order

$$g(x,t) = \exp\left[\frac{x}{2}\left(t - \frac{1}{t}\right)\right] = \sum_{n=-\infty}^{\infty} J_n(x)t^n$$

   Obtain the recurrence relation

$$J_{n-1}(x) + J_{n+1}(x) = 2\frac{n}{x}J_n(x)$$

   Also using the generating function show that
$$J_0(x) + 2J_2(x) + 2J_4(x) + 2J_6(x) + \cdots + 2J_{2k}(x) + \cdots = 1$$
(10)

2. a) Obtain orthogonality relation for Hermite polynomials using the generating function:

$$e^{2xt - t^2} = \sum_{n=0}^{\infty} H_n(x)\frac{t^n}{n!}$$
(10)

   b) i) Show that the following vectors

$$\begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}, \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix}$$
(2)

   are linearly independent.

   ii) The first Pauli matrix is

$$\sigma_1 = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$$

   calculate $U_1(\theta) = \exp(i\theta\sigma_1) = 1 + i\theta\sigma_1 = -\frac{\theta^2}{2}\sigma_1^2 - \cdots$

   For real θ, show that U_1 is unitary and has determinant 1.
(3)

c) Obtain the eigenvalues and eigenvectors of matrix A:

$$A = \begin{bmatrix} 2 & 0 & -1 \\ 0 & 2 & 0 \\ -1 & 0 & 2 \end{bmatrix}$$ (5)

d) Define covariant and cotravariant tensors of rank 2. Prove that $a_i = g_{ij}v^j$ transform covariantly, where g_{ij} are the components of the matrix tensor of rank 2 and v^i the components of a contravariant vector. (5)

PART B

3. a) i) Obtain the analytic function whose real part is

$$u(x, y) = e^x \cos y$$ (3)

   ii) Locate and name the singularity of the function:

$$\frac{z^2 - 2z}{z^2 + 2z + 2}$$ (2)

   b) Calculate the value of the integral $\oint_C \dfrac{\cos z}{z} dz$ when C is the circle $|z| = 2$. (5)

   c) Show that the Series $\displaystyle\sum_{n=1}^{\infty} z^n(1-z)$ converges for $|z| < 1$ and find its sum. (5)

   d) Obtain the Laurent series expansion of $\dfrac{e^z}{(z-1)^2}$ about $z = 1$. Determine the type of singularity and the region of convergence. (5)

   e) Evaluate the value of the contour integral $6\oint_C \dfrac{z\,dz}{(z-1)(z^2+9)}$ where C is a circle defined by $|z| = 4$. (5)

4. a) Evaluate the integral

$$\int_0^{2\pi} \frac{d\theta}{1 + p\cos\theta}$$

   by the method of residues when $-1 < p < 1$. (10)

   b) Consider a triangle T in the z-plane with vertices at i, $1-i$, $1+i$. Determine the triangle T_0 into which T is mapped under the transformations

$$w = iz + 2 - i$$ (5)

   c) Obtain the Fourier cosine transformation of the function:

$$f(x) = e^{-px}, \quad 0 < x < \infty, \quad p > 0$$ (5)

   d) Define homomorphisms. When do the homomorphisms become endomorphism and isomorphism? (5)

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