Course Code	Course Name	Credits
26PH511	MATHEMATICAL METHODS FOR PHYSICISTS	04

Course Objectives

- To find the different computational techniques for physics applications
- To study the types of elements and symmetry operations and constructing the character tables based on the principles of the group theory.
- To solve the differential equation using an appropriate numerical method and root finding methods Constructing a polynomial, like Newton Raphson & Gregory method for equally spaced points.
- To study the modules and structure of python programming.
- To study and use the arrays, control structures using python programming.

Learning Outcomes

After completion of the course, students will be able to:

- Understand group theory fundamentals including cyclic groups, subgroups, conjugate classes, symmetry operations, and molecular point group identification.
- Construct character tables for Cn groups (C2v, C3v), apply Great Orthogonality Theorem, and generate irreducible representations for symmetry analysis.
- Apply numerical methods like Trapezoidal/Simpson's rules for integration, Runge-Kutta for ODEs, and interpolation techniques (Newton, divided differences, Gregory-Newton) to physics problems.
- Install and use basic Python features: expressions, objects, lists, tuples, strings, loops, and development tools for scientific computing.
- Implement advanced Python with SciPy/NumPy for arrays, data import/export, visualization (histograms, contour plots), functions, random simulations, Fourier transforms, and sparse eigenvalue problems.

Unit 1 - Basics of Group Theory (12 Hrs.)

Definition and nomenclature - Rearrangement theorem - cyclic groups - subgroups - conjugate elements and class structure - identification of symmetry element and operations - molecular point groups.

Unit 2 – Representation of Cn Groups (12 Hrs.)

The Great Orthogonality Theorem (Qualitative treatments) - character of representation. Character table - Generating symmetry operators - construction of character tables - irreducible representation for C2v and C3v.

Unit 3 - Numerical Methods Applied to Physics Problems (12 Hrs.)

Numerical integration: Trapezoidal, Simpson's 1/3 rules - Truncation error - composite trapezoidal and Simpson's 1/3 rules. ODE: Second – order & Fourth-order Runge-Kutta methods for first order ODE. Interpolation: Newton Raphson Method - Newton's interpolation - Linear interpolation - Higher-order polynomials - Divided differences - Gregory - Newton forward and backward interpolation formulae - error in interpolation (no theory and derivation of formulae in the entire unit).

Unit 4 – Basics of Python (12 Hrs.)

Installing Python - Launch Python - Python modules - Python expression - objects and their methods - Lists - Tuples - Strings - Loops - Development Tools.

Unit 5 - Python Structure and Control (12 Hrs.)

SciPy and NumPy - arrays - array operations - scripts - contingent behavior - nesting – importing data - exporting data - visualizing data - Functions - random numbers and simulation - histograms and bar graphs - contour plots and surfaces - matrix library - Interpolation - Fourier Transform - Sparse eigenvalue problem.

Reference Books:

1. Joshi, A.W. (2010). Matrix and Tensors in Physics. New Age Publications.
2. Tinkham, M. (1974). Group Theory and Quantum Mechanics. McGraw Hill Ltd.
3. Venkataraman, M.K. (2013). Numerical Methods in Science & Engineering. National Pub. Co. Madras.
4. Jesse, M.K., & Philip, N. (2015). Python for Physical modelling. Princeton University Press Princeton and Oxford

Websites and eLearning Sources:

1. https://onlinecourses.nptel.ac.in/noc25_ph15/preview
2. https://youtu.be/OGCRccWi4OE?si=f7VJofa63ynjGdDW
3. https://youtu.be/Zpk0xWgqQkw?si=Dg2LBBP4fBALL3la

COs and Bloom's Taxonomy Mapping – 26PH511		
Course Outcomes	**On successful completion of this course, students will be able to**	**BTL**
CO1	Recall and explain the fundamental concepts of group theory, including symmetry operations, cyclic groups, and molecular point groups.	K1, K2
CO2	Apply group theoretical methods to construct character tables and determine irreducible representations for simple point groups.	K3
CO3	Apply numerical methods such as interpolation, integration, and Runge-Kutta techniques to solve physics problems.	K3
CO4	Analyze computational techniques and Python-based methods for solving scientific problems, including data handling and visualization.	K4
CO5	Develop Python programs using libraries such as NumPy and SciPy to simulate, model, and analyze physical systems.	K6

BTL (Bloom's Taxonomy Level) - K1 – Remembering, K2 – Understanding, K3- Applying, K4 – Analyse, K5- Evaluate and K6 - Create

Relationship Matrix – 26PH511													
Course Outcomes	**Programme Outcomes (POs)**						**Programme Specific Outcomes (PSOs)**						**Mean Score of Cos**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	
CO1	3	2	1	1	1	1	3	2	1	1	1	1	1.58
CO2	3	3	2	2	1	1	2	3	2	2	2	1	2.00
CO3	3	3	3	2	1	1	2	3	3	2	2	2	2.25
CO4	3	3	3	3	2	1	2	3	3	3	2	2	2.42
CO5	3	3	3	3	3	2	3	3	3	3	3	2	2.83
												Total	2.22

Mean Score: 3- High, 2- Medium/Moderate, 1-Low