ST. XAVIER’S COLLEGE (AUTONOMOUS), AHMEDABAD-9
FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS & ELECTRONICS

SEMESTER –VII

SYLLABUS

OF

BSc PHYSICS (HONOURS)

BASED ON UNDERGRADUATE CURRICULUM FRAMEWORK (NEP – 2020)

(Effective from Academic Year 2025)

Curriculum Framework for Semester – VII

Course	Title	Content		Credit
DSC-11 (Theory)	PHMC771C AI	U1	Introduction to AI, Evolution, and Subfields	4
		U2	Intuitive Machine Learning	
		U3	Introduction to R Programming and AI-Assisted Coding	
		U4	Domain-Specific Practical Application	
DSC-12 (Theory)	PHMC772C Condensed Matter and Classical Mechanics	U1	Band Theory	4
		U2	Free Electron in Crystal	
		U3	Variational Principle	
		U4	Canonical Transformations, Poisson Brackets and Small Oscillations	
DSC-13 (Laboratory)	PHMC773L Physics and Electronics Lab-VII	A	8-Physics Experiments	2
		B	8-Electronics Experiments	2
Research Project/OJT	PHRP771L/PHOJ771L			6
Minor (Theory + Lab)	PHMN771C Adv. Mathematical Physics & Quantum Mechanics -1	U1	Fourier and Laplace Transforms	3
		U2	Complex variables and Green's function	
		U3	Dirac Formalism and Matrix Mechanics	
		U4	Approximation Methods and Applications	1
Total Credits				**22**

* DSC: Discipline Specific Core

St. Xavier's College (Autonomous), Ahmedabad

Syllabus of Semester–VII to be implemented from the Academic Year **2026-27.**

DEPARTMENT OF PHYSICS & ELECTRONICS

Major Course: Adv.Mathematical Physics & Quantum Mechanics-1

Course Code & Title	Credit Distribution of The Course				Eligibility Criteria	Prerequisite(s) of the Course (if any)
	Cr	Lecture hrs	Tutorial hrs	Activity/Case study analysis		
PHMN771C: **Adv.Mathematical Physics & Quantum Mechanics-1**	4	12x4	3x4		10 + 2 from a recognized board	Science Stream Math-Group

Learning Objectives:

LO1	Understand Time vs Frequency Domain. Convert signals from time domain → frequency domain
LO2	Understand how different frequencies contribute to a signal. Apply Fourier Transform Techniques
LO3	Convert time-domain differential equations → algebraic equations. Understand the complex frequency domain (s-domain)
LO4	Solve Initial Value Problems. Use Transfer Functions
LO5	To develop a clear understanding of the operator formalism, Dirac notation, and matrix representation used in quantum mechanics.
LO6	To enable students to apply approximation methods such as perturbation theory and the variational principle to analyze realistic quantum systems.

Course Outcomes:

At the end of the course student will be able to

CO1	Use Fourier transforms and its inverse in practical applications of Physics
CO2	Apply Laplace transform and its inverse to solve initial value and other related problems
CO3	Have a working knowledge of differentiability for complex functions and be familiar with the Cauchy-Riemann equations
CO4	To evaluate integrals along a path in the complex plane and understand the statement of Cauchy's Theorem, use Green functions.
CO5	Use operator methods, commutators, and Dirac notation to represent and analyze quantum states and observables.
CO6	Apply time-independent perturbation theory and the variational method to calculate approximate energies and describe atomic systems in external fields.
CO7	Analyze spin-1/2 and two-level quantum systems using matrix mechanics and interpret physical phenomena such as Zeeman and Stark effects.

Unit 1: Fourier and Laplace Transforms

Credit of Course: 1 Cr **Lecture 12 Hrs** **Tutorial 3Hrs**

Integral transform: Integral transform: Introduction, Development of Fourier Integral, Fourier Transforms-Inversion Theorem, Fourier Transforms of derivatives, Laplace transforms, Laplace transform of Derivatives, Properties: Substitution and Translation, Derivative of Transform, Convolution theorem, Inverse Laplace Transform

Suggested Reading:

- Boas M.L., Mathematical methods in the physical sciences, JW,1966
- Chattopadhyaya P.K., Mathematical Physics, Wiley Eastern Ltd.
- Arfken G., Mathematical methods for Physicists, Academic Press, 1970

Unit 2: Complex variables and Green's function

Credit of Course: 1 Cr **Lecture 12 Hrs** **Tutorial 3Hrs**

Green's function method of solving inhomogeneous differential equations, Boundary Conditions, Application to One-dimensional problems. Cauchy-Riemann equations and their applications. Analytic and Harmonic Functions. Complex integrals. Cauchy's theorem (elementary proof only), converse of Cauchy's theorem, Cauchy integral formula and its corollaries, Series - Taylor and Laurent expansion, classification of singularities, branch point and branch cut, residue theorem and evaluation of some typical integrals using this theorem.

Suggested Reading:

- Mathematical Methods for Physicists by G. Arfken Weber, Academic Press, 6th Ed (2005)
- Mathematical Physics by P. K.Chattopadhyay (Wiley Ea tern Limited, (1990)
- Mathematical Methods for Physicists by G. Arfken Weber, Academic Press, 6th Ed (2005)

Unit 3: Dirac Formalism and Matrix Mechanics

Credit of Course: 1 Cr **Lecture 12 Hrs** **Tutorial 3Hrs**

State vectors and superposition. Inner product, normalization, orthogonality. Discrete and continuous basis; expansion of states. Linear operators and observables. Hermitian operators, eigenvalues, expectation values, and commutators. Measurement postulate and projection. Uncertainty principle. Dirac bra–ket notation; completeness and change of basis. Matrix representation of operators. Two-state systems and spin-1/2. Pauli matrices and measurement in spin systems.
Tutorials: Operator algebra and uncertainty; bra–ket manipulation and basis expansion; two-state systems and Pauli matrices.

Suggested Reading:

- Griffiths Ch. 3 (3.1–3.6)
- (Additional Practice) Zettili Ch. 3–5, 8 (selected)

Unit 4: Approximation Methods and Applications

Credit of Course: 1 Cr **Lecture 12 Hrs** **Tutorial 3Hrs**

Motivation for approximation methods. Time-independent perturbation theory: non-degenerate and degenerate cases; first- and second-order energy corrections; wavefunction correction (introductory). Applications: fine structure (qualitative), normal Zeeman effect, Stark effect. Variational principle and upper-bound theorem. Applications to hydrogen and helium (qualitative). Two-level approximation models. Tutorials: Non-degenerate perturbation; degenerate perturbation and matrix diagonalization; variational method problems.

Suggested Reading:

- Griffiths Ch. 6 (6.1–6.4), Ch. 7 (7.1–7.2)
- (Additional Practice) Zettili Ch. 11–13