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

DEPARTMENT OF PHYSICS & ELECTRONICS

SEMESTER –VI

SYLLABUS

OF

BSc PHYSICS (HONOURS)

BASED ON UNDERGRADUATE CURRICULUM FRAMEWORK (NEP – 2020)

(Effective from Academic Year 2025)

Curriculum Framework for Semester – VI

Course	Title	Content		Credit
DSC-8 (Theory)	PHMC661C Adv. Mathematical Physics & Statistical Mechanics	U1	Some Special Functions	4
		U2	Matrices and Vector Spaces	
		U3	Foundations of Statistical Mechanics	
		U4	Ensemble Theory and Applications	
DSC-9 (Theory)	PHMC662C Spectroscopy	U1	Raman and Electronic Spectroscopy	4
		U2	Molecular Rotation and Vibration: Spectroscopic Analysis	
		U3	Atomic Spectroscopy	
		U4	X-ray, NMR, and ESR Spectroscopy	
DSC-10 (Laboratory)	PHMC443L Physics and Experiential Lab-VI	14	Physics Experiments	2
		Project	Experiential Lab	2
INTERNSHIP	PHIN661C	Outside the college campus: with industries, research institution, academic institution, social institution/NGO etc		4
Minor (Theory + Lab)	PHMN661C Analog Devices and Transistor Amplifiers	U1	Special Semi-Conductor Devices	3
		U2	Feedback in Amplifiers	
		U3	Frequency Response of a Transistor Amplifier	
		U4	Laboratory	1
AEC	Ability Enhancement Course	* (To be offered by the concerned subject Department)		2
Total Credits				**22**

* DSC: Discipline Specific Core

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Syllabus of Semester–V to be implemented from the Academic Year **2025-26.**

DEPARTMENT OF PHYSICS & ELECTRONICS

Major Course: Mathematical Physics & Statistical Mechanics

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		
PHMC661C: Adv. Mathematical Physics & Statistical Mechanics	4	12x4	3x4		10 + 2 from a recognized board	Science Stream Math-Group

Learning Objectives:

LO1	To introduce the fundamental concepts and postulates of statistical mechanics and their connection with thermodynamics
LO2	To develop understanding of classical ensembles and their applications to physical systems
LO3	To provide analytical tools for calculating thermodynamic quantities from microscopic models
LO4	To train students in applying statistical methods to gases, solids, and model systems through problem-solving.

Course Outcomes:

CO1	Apply and analyze several new functions in open ended problems that may cross disciplinary area boundaries using creative and critical thinking.
CO2	Apply knowledge of matrices and determinants to other branches of Physics.
CO3	Explain the statistical basis of thermodynamics and entropy.
CO4	Apply ensemble theory (microcanonical, canonical, and grand canonical) to simple physical systems
CO5	Derive thermodynamic properties from partition functions and evaluate relevant physical quantities
CO6	Solve standard problems in classical statistical mechanics involving gases, solids, and model systems.

Unit 1: Some Special Functions:

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

Bessel function, recurrence relations satisfied by Bessel's functions, Integral representation of Bessel function, Orthogonality, Neumann function, Bessel functions of the second kind, Henkel functions, Spherical Bessel functions, Legendre polynomials, Associated Legendre polynomials and spherical harmonics, Hermite polynomials, Laguerre polynomials,

Suggested Reading:

Mathematical Physics by P K Chattopadhyay (New Age International Publishers)
Mathematical Methods for Physicists by G. Arfken, Academic Press 10
Mathematical Methods in the Physical Science by Mary L Boas, Wiley India Pvt. Ltd

Unit 2: Matrices and Vector Spaces:

Vector spaces and basis, inner product and norms, linear operators, matrix representation of operators and vectors, basic matrix algebra, functions of matrices, transpose/conjugate and trace, determinants and inverse, rank and special matrices, eigenvalues and eigenvectors, diagonalization, change of basis, similarity. (Optional, if time permits: solving linear systems of equations and singular value decomposition (SVD)). [AR]

Text Book:
Mathematical Methods for Physics and Engineering by KF Riley, MP Hobson and SJ Bence; Cambridge University Press.

Unit 3: Foundations of Statistical Mechanics (10 Lectures)

First and Second laws combined; limitations of laws of thermodynamics. (Revision, qualitative). Thermodynamic work – for magnetic, dielectric, elastic systems. Legendre transformations & thermodynamic potentials – U, F, H, G. Microstates, macrostates, and statistical postulate. Classical phase space, density, Liouville's theorem. Statistical origin of entropy – application to ideal gas, Gibbs paradox & correction term.

Suggested Reading: Pathria Ch.1; Reif Ch.1–3

Unit 4: Ensemble Theory and Applications (14 Lectures)

Concept of ensembles and postulates. Microcanonical ensemble: entropy & temperature. Canonical ensemble: partition function, free energy, thermodynamic functions. Applications of canonical ensemble: ideal monatomic gas, equipartition theorem, virial theorem, Dulong–Petit law of specific heat of solids. Grand canonical ensemble: partition function, thermodynamic variables, particle number fluctuations, simple applications.

Suggested Reading: Pathria Ch.2–4 (selected sections), Reif Ch.6–7 (selected sections)

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Syllabus of Semester–VI to be implemented from the Academic Year **2025-26.**

DEPARTMENT OF PHYSICS & ELECTRONICS

Major Course: Spectroscopy

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		
PHMC661C: Spectroscopy	4	12x4	3x4		10 + 2 from a recognized board	Science Stream Math-Group

Learning Objectives:

LO1	Understand and apply the principles of Raman, IR, and electronic spectroscopy to explain molecular interactions, analyze spectra using classical and quantum approaches, and determine molecular structures and properties.
LO2	Students will be able to understand molecular energy states, explain the Born-Oppenheimer approximation, and analyze rotational and vibrational-rotational spectra using physical models such as rigid/non-rigid rotators and harmonic/anharmonic oscillators, including isotope and fine structure effects.
LO3	Students will be able to understand electron spin, angular momentum coupling (L-S and j-j), Pauli's exclusion principle, fine structure, Zeeman and Stark effects, and analyze energy levels and spectral transitions of atoms.
LO4	Students will be able to explain the production, properties, and spectra of X-rays, and understand the principles, instrumentation, and applications of NMR and ESR spectroscopy.

Course Outcomes:

CO1	To understand molecular spectroscopy by analyzing vibrational, rotational, and electronic structures, and applying Raman, IR, and electronic spectra for molecular characterization.
CO2	To understand molecular energy states and the Born-Oppenheimer approximation, and to interpret rotational and vibrational-rotational spectra using rigid/non-rigid rotator and harmonic/anharmonic oscillator models.
CO3	To understand the principles of atomic structure, electron spin, angular momentum coupling, fine structure, and external field effects, and to interpret the energy levels and spectra of atoms including helium and alkali elements.
CO4	To understand X-ray generation and spectra, and to explore the principles, instrumentation, and applications of NMR and ESR for analysing atomic and molecular systems.

Unit 1: Raman and Electronic Spectroscopy

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

[A] Raman Spectra: Nature of the Raman spectra, experimental arrangement for Raman spectra, Classical
in emission, electronic band spectra in absorption, Rotational structure of electronic bands; Rotational structure
of three theory of Raman effect, Quantum theory of Raman effect, Raman spectra and Molecular structure, Infrared spectra versus Raman spectra
[B] Electronic Spectra: Electronic Spectra, salient features, formation of electronic spectra, Vibrational (Gross) structure of electronic band system branch bands.

Textbook: Atomic & Molecular Spectra: Laser by Rajkumar
Publication: Kedarnath Ramnath Meerut
Article: [A] Chapter 20 Articles: 1 to 6, [B] Chapter 21 Articles 1 to 7

Unit 2: Molecular Rotation and Vibration: Spectroscopic Analysis

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

[A] Types of Molecular Spectra and Molecular Energy States: Separation of electronic and nuclear motion
- The Born Oppenheimer approximation, types of molecular spectra and techniques.
[B] Pure Rotational Spectra: Salient features of Rotational spectra, Molecular requirement for rotation spectra, experimental arrangement, Molecule as a rigid rotator, explanation of rotational spectra (without the process of solving Schrodinger equation to get energy formula), the non-rigid rotator, Isotope effect on rotational spectrum, tunable laser and pulse laser introduction
[C] Vibrational Rotational Spectra: salient features of vibrational Rotational spectra, Molecule as a harmonic oscillator, Molecule as anharmonic oscillator, Vibrational frequency and force constant for anharmonic oscillator, Fine structure of Infrared bands.

Textbook: Atomic & Molecular Spectra: Laser by Rajkumar
Publication: Kedarnath Ramnath Meerut
Article: [A] Chapter 17 article 1,2; [B] Chapter 18 article 1 to 6; [C] Chapter 19 article 1 to 4, 6

Unit 3: Atomic Spectroscopy

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

Stern Gerlach experiment, electron spin, The vector atom model, Spin-orbit interaction and fine structure, Pauli's exclusion principle and electronic configuration, Total angular momentum in many electron atoms, L-S coupling, j-j coupling, Hund's rules, Energy levels and transitions of Helium, Alkali spectra, Shielding of core electrons, Spectral terms of equivalent electrons, Normal Zeeman effect, experimental arrangement and theory, Anomalous Zeeman effect, Paschen-Bach effect, Stark effect.

Textbook: Modern Physics by Aruldhas
Publication: Kedarnath Ramnath Meerut
Article: 7.4 to 7.16

Unit 4: X-ray, NMR, and ESR Spectroscopy

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

[A] X-rays: Introduction, Production of X-rays, properties of X-rays, Continuous and Characteristic X-ray Spectra, Origin of X-rays of Moseley's Law, Absorption of X-rays, X-ray Spectra.

[B] NMR and ESR: Nuclear Magnetic Resonance principle, The NMR Spectrometer, Chemical Shifts, Indirect Spin-Spin Interaction, Application of NMR. Electron Spin Resonance principle, ESR Spectrometer, Hyperfine Interaction, Application of ESR Spectroscopy.

Textbook:
[A] Atomic and Nuclear Physics by Brij lal and N. Subrahmanyam, Publication: S. Chand
Article: 6.1 to 6.7
[B] Modern Physics by G. Aruldhas and P. Rajagopal, Publication: PHI
Article: 9.13, 9.14

Reference Books:

1. Spectroscopy (Atomic and Molecular) by G Chatwal and S Anand.
2. Fundamentals of Molecular Spectroscopy by C N Banvel
3. Elements of Spectroscopy by Gupta, Kumar and Sharma (Pragati Prakashan Meerut)
4. Modern Physics by Arthur Beiser
5. Modern Physics by Kenneth Krane

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Syllabus of Semester–VI to be implemented from the Academic Year **2025-26.**

DEPARTMENT OF PHYSICS & ELECTRONICS

Major Course: Physics Lab and Experiential Lab-VI

Course Code & Title	Credit Distribution of The Course			Eligibility Criteria	Prerequisite(s) of the Course (if any)
	Cr	Laboratory Hrs per week	Activity/Case study analysis		
PHMC663L: **Physics Lab and Experiential Lab-VI**	4	8		10 + 2 from a recognized board	Science Stream Math-Group

LEARNING OBJECTIVES (LO)
(Physics Laboratory)

LO1	Understand reversible pendulum principle; perform precise time period measurement; analyse errors in *g*.
LO2	Calibrate various optical instruments like Babinet compensator and Michelson Interferometer and use them to analyse the elliptically polarised light and finding the wavelength difference of sodium doublet
LO3	Understand charged oil drop motion; measure terminal velocity; verify charge quantization.
LO4	Study the magnetic properties like permeability, measure magnetic field with/without core; analyse induction effects, study the Hall effect of a single crystal by two probe method.
LO5	Understand AC bridge principle; measure mutual inductance and self inductance; analyze balance condition.
LO6	Understand stress-strain optics; relate fringe shift to strain; calculate Young modulus.
LO7	Understand thermal vs. electrical conductivity; verify law; calculate Lorenz number.

(Experiential Lab.)

LO1	Independently identify the aim of a basic experiment with a creative or modified twist.
LO2	Collaboratively understand the problem and set up the complete experiment through self-learning in a team of 2–3 students. Present the results obtained and inferences drawn.
LO3	Analyze potential sources of error and assess their impact on the results.

Course Outcomes (CO)
(Physics Laboratory)

CO 1	Apply oscillatory motion concepts, and concepts of electromagnetism and magnetism to study of a semiconductor with the use of Hall setup and determine permeability with/without core
CO 2	Correlate thermoelectric effect with thermal processes; apply data analysis to exponential decay.
CO 3	Compute key electrical and magnetic constants such asHall coefficient, **permeability,** and **self-inductance** using standard electromagnets and solenoids.
CO 4	Apply wave optics principles in interferometry and polarisation; enhance skills in high-precision optical measurements
CO 5	Apply elasticity concepts through optical techniques; achieve precise measurement of material properties.
CO 6	Apply solid-state physics to verify material laws; relate thermal and electrical conductivity.

(Experiential Lab.)

CO 1	Set up and demonstrate new experiments to verify assigned physics principles and measure physical quantities.
CO 2	Independently calculate errors in measured results.
CO 3	Present and submit the experiment in the form of a scientific report.

B.Sc. (PHYSICS) SEMESTER -VI PH-PHMC6613L (Practical)

01	Acceleration due to gravity by Kater's pendulum (variable knife edges.)
02	Decay Of temperature using Thermocouple.
03	To study the Hall effect and find the Hall coefficient.
04	To determine the charge on electron by Millikan's experiment.
05	To find the value of permeability of free space & ferromagnetic core.
06	Michelson interferometer-To determine "d λ " of close doublets of sodium light.
07	To calibrate the spectrometer using Edser-Butler plate.
08	To analyse elliptically polarized light using Babinate's compensator.
09	To measure helical pitch and diameter of spring using diffraction pattern.
10	Young's modulus by Optical method.
11	Mutual inductance bridge by carry's faster's.
12	Self inductance of a coil by Rayleigh's method.
13	Weidman franz law.
14	Study of Hysterisis using C.R.O.