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

DEPARTMENT OF PHYSICS & ELECTRONICS

SEMESTER – IV

SYLLABUS

OF

BSc PHYSICS (HONOURS)

BASED ON UNDERGRADUATE CURRICULUM FRAMEWORK
(NEP – 2020)

(Effective from Academic Year 2023)

Curriculum Framework for Semester – IV

Course	Title	Content		Credit
DSC-8 (Theory)	PHMC441C Modern Physics and Nuclear Physics	U1	Modern Physics	4
		U2	Special Relativity	
		U3	Nuclear Physics	
		U4	Nuclear Physics: Instrumentation	
DSC-9 (Theory)	PHMC442C Electromagnetism and Thermal Physics	U1	Magnetic Field in Matter	4
		U2	Electric Field in Matter	
		U3	Kinetic Theory and Thermoelectricity	
		U4	Thermodynamics	
DSC-10 (Laboratory)	PHMC443L Physics and Experiential Lab-IV	14 Physics Experiments		4
		Experiential Lab		
Minor-1 (Theory + Lab)	PHMN441C Basic Physics-III	U1	Electric Field in Matter	2
		U2	Kinetic Theory and Thermoelectricity	
		U3 U4	14 Physics Experiments	2
Minor-1 (Theory + Lab)	ELMN441C Basic Electronics-III	U1	Voltage Regulators	2
		U2	Impedance Transformer and Coupled Circuits	
			14 Experiments	2
SEC	PHSE441C Arduino (Swayam)	U1	Arduino	2
		U2	Laboratory Component	
AEC	Ability Enhancement Course	(To be offered by the concerned subject Department)		2
VAC	Value Added Course	(To be chosen from a basket of courses)		2
Total Credits				**22**

* DSC: Discipline Specific Core

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

DEPARTMENT OF PHYSICS & ELECTRONICS

Major Course: Modern Physics and Nuclear Physics

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		
PHMC441C: Modern Physics and Nuclear Physics	4	12x4	3x4		10 + 2 from a recognized board	Science Stream Math-Group

Learning Objectives:

LO1	Analyze the limitations of classical physics and understand the motivation behind the development of modern physics and theory of relativity
LO2	Apply Lorentz transformations and relativistic formulas to solve problems involving time dilation, length contraction, and mass-energy equivalence.
LO3	Evaluate radioactive decay processes, both natural and artificial, and calculate decay rates, half-lives, and remaining activity in a sample over time.
LO4	Understand the interaction of particles with matter and explore the construction and function of common radiation detectors and particle accelerators.

Course Outcomes:

CO1	Understand and apply the principles of modern physics, including black body rations, photoelectric effect, Compton effect, dual nature of light, and atomic spectra, to solve practical physics problems.
CO2	Demonstrate an understanding of special relativity, including space-time transformations and relativistic mechanics, with applications in real-life and astronomy-related problems.
CO3	Apply concepts of natural and artificial radioactivity to real-world applications such as carbon dating, radioactive decay analysis, and understanding Earth's age.
CO4	Explain the working principles and applications of nuclear detectors and particle accelerators, including Geiger counters, cloud chambers, cyclotrons, and synchrotrons.

Unit 1: Modern Physics

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

Blackbody Radiation, Photoelectric effect; X-rays; X-ray diffraction; Compton effect; Wave-particle, duality; Uncertainty principle. Franck-Hertz experiment; Atomic spectra; Bohr's atomic model; Energy levels and spectra; Correspondence principle.

Text Book:

- Concepts of Modern Physics by Arthur Beiser – Chapters 2 and 3

Unit 2: Special Relativity

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

Special Relativity, Time Dilation, Doppler Effect, Length Contraction, Faster means shorter, Twin Paradox, Electricity and Magnetism, Relativistic Momentum, Mass and Energy, Energy and Momentum, General Relativity.

Text Book

- Modern Physics by Aruldhas and Rajagopal – Articles 1.1 – 1.11

Unit 3: Nuclear Physics

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

Radioactivity: The law of radioactive decay (review), Radioactive growth and decay, ideal equilibrium, Transient equilibrium and secular equilibrium, Radioactive series, Radioactive isotopes of lighter elements, Artificial radioactivity, Age of earth, Carbon dating (Archaeological time scale).

The Q Equation: Types of Nuclear Reactions, The balance of mass and Energy in Nuclear reactions, The Q Equation, Solution of the Q Equation. Constituents of the nucleus properties: Measurement of Nuclear radius, Constituents of the nucleus and their properties, Nuclear spin, moments and statistics. Methods of measurement of half-life.

Text Book

- Nuclear Physics by SB Patel – Articles 2.3 – 2.13, 3.1 – 3.5

Unit 4: Nuclear Physics – Instrumentation

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

Introduction, Interaction between particles & Matter, brief survey, Detectors for Nuclear particles (i) Proportional counter (ii) The Geiger counter (iii) Scintillation counter (iv) Solid state or semiconductor detectors (v) Cloud & Bubble chambers (vi) Spark chamber

Particle Accelerators: Need for an accelerator of charged particles, (i) Van de Graff Generator (ii) The cyclotron (iii) Synchrotron (iv) The Betatron; Beta ray spectrometer.

Text Book:

- Nuclear Physics by SB Patel – Articles 1.1.1 – 1.1.5, 3.1 – 3.5, 4.1.3 – 4.1.5

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

DEPARTMENT OF PHYSICS & ELECTRONICS

Major Course: Electromagnetism and Thermal Physics

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		
PHMC442C: Electromagnetism and Thermal Physics	4	12x4	3x4		10 + 2 from a recognized board	Science Stream Math-Group

Learning Objectives:

LO1	Understand and interpret the concepts of polarization, bound charges and electric displacement in dielectric materials subjected to electric fields.
LO2	Analyze magnetization in matter, including the study of diamagnetism, paramagnetism, ferromagnetism, and hysteresis behavior using fundamental principles.
LO3	Apply the principles of classical thermodynamics to understand processes like isothermal, adiabatic, and Carnot cycles, and relate them to practical engines and systems.
LO4	Lean and apply the kinetic theory of gases, including Maxwell's speed distribution, mean free path, and related experimental verifications to understand gas behavior.

Course Outcomes:

CO1	Demonstrate a strong understanding of magnetostatics and dielectric behavior in matter, including concepts such as bound currents, vector potential, polarization, and electric displacement fields.
CO2	Apply Ampere's law and boundary conditions to solve problems involving magnetic and electric fields in dielectric and magnetic materials.
CO3	Evaluate thermodynamic systems using the laws of thermodynamics, Carnot cycle, and Maxwell's relations to describe energy transformations.
CO4	Analyze the behavior of ideal gases and statistical distributions, specifically Maxwell's speed distribution and mean free path theories, in thermal physics applications.

Unit 1: Magnetic Field in Matter

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

Magnetization: Diamagnets, Paramagnets, Ferromagnets, Torques and Forces on Magnetic Dipoles, Effect of Magnetic Field on Atomic Orbits, Magnetization. The Field of a Magnetized Object: Bound currents, Physical Interpretation of Bound currents, The Magnetic field inside Matter. The Auxiliary Field H: Ampere's law in Magnetized Materials, Deceptive Parallel, Boundary Condition, Linear and Non Linear Media: Magnetic Susceptibility and Permeability, Ferromagnetism.

Text Book:

- Introduction to Electrodynamics vy David J. Griffiths – Articles 6.1.1 – 6.1.4, 6.2.2 – 6.2.3, 6.3.1 – 6.3.3, 6.4.1 – 6.4.2

Unit 2: Electric Field in Matter

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

Polarization: Dielectrics, Induced dipoles, alignment of polar molecules, field of a polarized object, Physical interpretation of bound charges, the field inside a dielectric.

The Electric Displacement: A deceptive parallel, boundary conditions. Linear Dielectrics: Boundary value problems with linear dielectrics, Energy in dielectric systems. Forces on dielectric

Text Book

- Introduction to Electrodynamics vy David J. Griffiths – Articles 4.1, 4.1.2 – 4.1.3, 4.2.1 – 4.2.3, 4.4, 4.4.1 – 4.4.4

Unit 3: Kinetic Theory and Thermoelectricity

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

Introduction, Assumption of the kinetic theory, Deduction of ideal gas equation, Deduction from pressure expression, Kinetic theory and molecular chaos, Distribution of speeds, Maxwell's velocity or speed distribution law, Average speed, r.m.s. Speed, Most probable speed, Degree of freedom of a dynamical system, principal of classical equipartition of energy, Degree of freedom and ratio of heat capacities, Dulong and Petit's law, Mean free path, Isotherms and deviations from ideal gas, van der Waals equation of state, Critical constants of van der Waals gas.

Thermoelectricity: Seeback effect, Peltier effect, Thomson effect, Total emf in thermocouple.

Text Book

- Thermal Physics by AB Gupta and HP Roy – Articles 2.1 – 2.22 (Chapter 2)

Unit 4: Thermodynamics

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

Zeroth law and concept of thermal equilibrium. First law and its consequences. Isothermal and adiabatic processes. Reversible, irreversible and quasi-static processes. Second law and entropy. Carnot cycle. Maxwell's thermodynamic relations and simple applications. Thermodynamic potentials and their applications. Phase transitions and Clausius-Clapeyron equation.

Text Book:

- Thermal Physics by Blundell and Blundell – Chapter 13, 14 (article 14.1), 16, 28 (articles 28.1 – 28.3)
- Thermal Physics by Garg, Bansal and Ghosh – Articles 4.1 – 4.6, 5.4, 6.1 – 6.4

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

DEPARTMENT OF PHYSICS & ELECTRONICS

Major Course: Physics Lab and Experiential Lab – IV

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		
PHMC443L: Physics Lab and Experiential Lab - IV	4	8		10 + 2 from a recognized board	Science Stream Math-Group

Learning Objectives:
(Physics Laboratory)

LO1	The students will have a good foundation in the fundamentals related to the experiments included in this course and their advanced applications.
LO2	They will learn to handle instruments such as Multimeters, Ballistic Galvanometer, Spectrometer, Telescopes and Microscopes, make accurate measurements, analyse data, and report results effectively.
LO3	They will be able to perform experiments on identifying elements present in line spectra, polarization, determining high resistance by method of leakage, applications of solar cell, lattice constant, positive and negative crystals etc.

Learning Objectives:
(Experiential Laboratory)

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
LO3	Analyse potential sources of error and assess their impact on the results.

Course Outcomes:
(Physics Laboratory)

CO1	The course objectives include: understanding measurement techniques.
CO2	Demonstrating knowledge of experimental physics concepts, constructing and analyzing circuits,
CO3	Estimating errors, and relating textbook physics to real-world observations
CO4	To bridge the gap between theory and experiment.

Course Outcomes:
(Experiential Laboratory)

CO1	Set up and demonstrate new experiments to verify assigned physics principles and measure physical quantities.
CO2	Independently calculate errors in measured results.
CO3	Present and submit the experiment in the form of a scientific report.

List of Practical

S. No.	Experiment
1	Double refraction in calcite prism (To be investigated by polarizer)
2	Resolving power of grating
3	Identification of elements in line spectra
4	Analysis of elliptical polarized light.
5	Determine dielectric constant
6	High resistance by leakage method.
7	Searle's goniometer
8	C_1/C_2 by Desauty's method
9	'C' by ballistic galvanometer
10	Shunt regulator
11	To measure Permeability of free space
12	L by Anderson's bridge.
13	Solar Cell
14	Study of electron Diffraction Pattern