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

DEPARTMENT OF PHYSICS & ELECTRONICS

SEMESTER – III

SYLLABUS

OF

BSc PHYSICS (HONOURS)

BASED ON UNDERGRADUATE CURRICULUM FRAMEWORK
(NEP – 2020)

(Effective from Academic Year 2023)

Curriculum Framework for Semester – III

Course	Title		Content	Credit
DSC-5 (Theory)	PHMC331C Solid State Physics and Classical Mechanics	U1	Interatomic Forces and Bonding Force in Solids, The crystalline State.	4
		U2	Lattice Vibrations, Thermal properties	
		U3	Lagrangian Formulation, Motion of a rigid body	
		U4	Classical Mechanics, Moving Coordinate System	
DSC-6 (Theory)	PHMC332C Optics and Instrumentations	U1	Diffraction and Resolving power	4
		U2	Polarization	
		U3	Lasers	
		U4	Instruments	
DSC-7 (Laboratory)	PHMC333L Physics and Experiential Lab-III		14 Physics Experiments	4
			Experiential Lab: Hands on experiment.	
SEC	PHSE331C Physics Analysis using Python	U1	Introduction to Python Programming.	2
		U2	Python Laboratory	
MDC	MDC206C Astronomy for Beginners	U1	Intr. to Astronomy and Observations in Astronomy	4
		U2	Principles and Tools for Observations in Astronomy	
		U3	Celestial Objects and Their Nature	
		U4	Field Trip/Project/Stargazing	
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–III to be implemented from the Academic Year **2025-26.**

DEPARTMENT OF PHYSICS & ELECTRONICS

Major Course: Solid State Physics and Classical Mechanics						
Course Code & Title	**Cr**	Lecture hrs	Tutorial hrs	Activity/Case study analysis	**Eligibility Criteria**	**Prerequisite(s) of the Course (if any)**
PHMC331C Solid State Physics and Classical Mechanics	4	12 × 4	3 × 4		10 + 2 from a recognized board	Science Stream Math-Group

Learning Objectives:

LO1	Describe different types of atomic bonds (ionic, covalent, metallic, van der Waals) and explain how they affect molecular and crystal properties.
LO2	Identify and analyze crystal symmetries, lattice types, and use X-ray and electron beam techniques to investigate crystal structures and reciprocal space.
LO3	Understand and derive lattice vibration models for monoatomic and diatomic chains, and explain the concept and significance of phonons in solids.
LO4	Compare and apply Newtonian and Lagrangian mechanics in real-world and physics-related problems to analyze motion and energy systems effectively.

Course Outcomes:

CO1	Understand the formation and properties of atomic bonds and analyze how different types of bonds determine the structural and physical properties of materials.
CO2	Analyze crystal structures and symmetry using the concepts of lattice, basis, and unit cells, especially focusing on cubic systems and reciprocal lattice.
CO3	Comprehend lattice vibrations and phonons and relate them to thermal properties such as specific heat, thermal conductivity, and thermal expansion using classical and quantum models.
CO4	Apply Newtonian and Lagrangian formulations to understand and solve mechanical problems in physical systems.

Unit 1: Solid State Physics

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

[A] InterAtomic Forces and Bonding Force in Solids: Cohesion of atoms; Primary bonds, Covalent bond, metallic bond, ionic bond, mixed bonding; Secondary bonds: Van der Waals bond, hydrogen bond, Cohesive energy, Madelung energy of ionic crystal.

[B] The crystalline State: Crystalline, polycrystalline and glassy materials; Basis of crystal structure; Unit cell-Primitive cell structures; Symmetry operations- translation, point, hybrid operations; Classification of Crystal types-two dimensional crystal lattice and three dimensional crystal lattices; Indices of a lattice direction and a lattice plane (Miller indices); Crystal point groups and space groups, space groups, space groups; Common crystal structures, simple cubic structure, BCC, FCC, closed packed and hexagonal close-packed structure, diamond structure, Reciprocal lattice, Construction of reciprocal lattice, Relationship between a, b, c and a*, b*, c*, Experimental Diffraction Methods, Laue method, Rotating crystal method, powder method, Determination of lattice constants; Selection of incident beam

Text Book:

[A] Solid State Physics by S O Pillai. Article: - 3.1 to 3.9

[B] Solid State Physics by S O Pillai Article: - 4.1 to 4.22, 4.25

Reference Books:

[A] Solid State Physics by Rita John and J. S. Blackmore

Unit 2: Solid State Physics

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

[A] Lattice Vibrations: Harmonic crystals, the “Ball & strings” model; Normal modes of one-dimensional monoatomic lattice, periodic boundary condition, concept of the first Brioullin zone, salient features of the dispersion curve; Normal modes of one- dimensional diatomic lattice, salient features of the dispersion curves, optical and acoustical mode; Quantization of lattice vibrations-phonons; Measurement of phonon dispersion by inelastic neutron scattering.

[B] Thermal properties: Classical lattice heat capacity Quantum theory of lattice heat capacity, Einstein model, phonon density of states; Debye continuum model; Anharmonic effects, Thermal expansion, Gruneisen parameter; Phonon collision processes, Phonon thermal conductivity.

Text Book

[A] Introduction to Solid State Physics by Arun Kumar, PHI, 5.1, 5.2, 5.3, 5.3.2, 5.4(Excluding 5.4.1 to 5.4.3), 5.5

[B] Solid State Physics by S.O. Pillai, New Age Publication, 7.1 to 7.5

Reference Books:

[A] Solid State Physics by Rita John and J. S. Blackmore

Unit 3: Lagrangian Formulation

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

[A] Introduction, Constraints, holonomic and non-holonomic constraints, scleronomous and theonomous constraints, generalized coordinates, D’alembert’s principle, La- grange’s equations, a general expression for kinetic energy, Symmetries and the laws of conservation, Cyclic or ignorable coordinates (including illustrations), Velocity dependent potential of electromagnetic field, Rayleigh’s dissipation function.

[B] Motion of a rigid body: Introduction, Euler’s theorem, Angular momentum and kinetic energy, The inertia tensor, Euler’s equations of motion, Torque free motion, Euler’s Angles.

Text Book

[A] Introduction to Classical Mechanics by R. G. Takawale and P. S. Puranik, Tata McGraw-Hill Publishing Co. Ltd, 8.1 to 8.9, 10.1 to 10.7

Reference Books:

[A] Classical Mechanics by A. B. Bhatia, Narosa Publication

[B] Classical Mechanics by H. Goldstein, Addison Wesley

[C] Classical Mechanics by J. C. Upadhyay, Himalaya publications

[D] Classical Mechanics by Rana and Jog

Unit 4: Classical Mechanics

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

[A] Motion in a Central force field: General features of the motion, Motion in an inverse square law force field, Equation of the orbit, Kepler's laws of planetary motion Collision of particles: Elastic & inelastic scattering, Elastic Scattering: Laboratory & Centre of mass system, Kinematics of elastic scattering in the laboratory system, inelastic scattering, cross- section, The Rutherford formula.

[B] Moving Coordinate System: Rotating coordinate system, The Coriolis force, Motion on the earth, Effect of Coriolis force on freely falling particles.

Text Book:

[A] Introduction to Classical Mechanics by R. G. Takawale and P. S. Puranik, Tata McGraw-Hill Publishing Co. Ltd, 5.2,5.3,5.6, 7.1 – 7.6, 9.1- 9.5

Reference Books:

[A] Classical Mechanics by A. B. Bhatia, Narosa Publication
[B] Classical Mechanics by H. Goldstein, Addison Wesley
[C] Classical Mechanics by J. C. Upadhyay, Himalaya publications
[D] Classical Mechanics by Rana and Jog

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

<u>DEPARTMENT OF PHYSICS & ELECTRONICS</u>

Major Course: Optics and Instrumentations						
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		
PHMC332C Optics and Instrumentations	4	12 × 4	3 × 4		10 + 2 from a recognized board	Science Stream Math-Group

Learning Objectives:

LO1	Explain and distinguish between Fresnel and Fraunhofer diffraction, study diffraction through single, double, and multiple slits, and calculate resolving power of diffraction gratings and other optical systems.
LO2	Understand the nature of sound, noise, and music, and apply this knowledge practically, including in voice and singing applications.
LO3	Describe and compare the working of zone plates with convex lenses, and analyze diffraction through different geometries.
LO4	Explain laser operation principles, differentiate types of lasers based on excitation methods, and describe their applications in various fields.

Course Outcomes:

CO1	Analyze diffraction phenomena in wave optics and apply the concepts of resolving power and Rayleigh's criterion to evaluate the performance of optical instruments like gratings and prisms.
CO2	Analyze diffraction patterns from different apertures, distinguish between Fresnel and Fraunhofer diffraction, and explain the working and comparison of zone plates with lenses.
CO3	Evaluate the resolving power of optical instruments, such as telescopes and diffraction gratings, and understand the limitations of optical resolution.
CO4	Comprehend the principles and functioning of lasers, including the construction, working, and applications of Ruby and He-Ne lasers, and the criteria for lasing action.

Unit 1: Diffraction and Resolving power

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

[A] **Wave Optics:** Diffraction of Light (Fresnel class): Frensnel's half period zones, zone plate, difference between interference & diffraction, Fresnel & Fraunhofer diffraction.

[B] **Fraunhofer class:** Fraunhofer diffraction at two slits, diffraction at N slits, Plane diffraction power of the grating.

[C] **Resolving power of optical Instrument:** Resolving power, Rayleigh's criterion of resolution, resolving power of a plane diffraction grating, difference between resolving power & dispersive power of grating, comparison of prism & grating spectra.

Text Book:

[A] A textbook of Optics by Dr N Subrahmanyam, Brij Lal, Dr. M N Avadhanulu, Articles 17.1,17.2,17.3,17.4,17.5,17.5.1,17.5.2, 17.6,17.7, 18.1, 18.2, 18.2.1, 18.4, 18.4.2, 18.4.3, 18.5, 18.6, 18.7, 19.1, 19.2, 19.5, 19.6,19.7, 19.12

Reference Books:

[A] Optics & atomic physics by Singh, Agrawal, Pragati Prakashan, Meerut
[B] A. Ghatak, Physical Optics
[C] D. P. Khandelwal, Optics and Atomic Physics

Unit 2: Polarization:

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

[A] **Optics:** Double refraction or birefringence, geometry of calcite crystal, Optical axis principal section principal plane, Nicol prism, Parallel Crossed Nicol prism, Huygen's theory of double refraction in uniaxial crystals, refractive indices for o-rays e-rays, Polaroids.

[B] **Production Analysis of Polarized light:** Introduction, superposition of two plane polarized waves having perpendicular vibrations, The elliptically circularly polarized light, quarter wave plate, half wave plate, production of plane elliptically circularly polarized light, detection of plane elliptically circularly polarized light, systematic analysis of polarized light. Babinet principle and compensator

[C] **Dispersion and Scattering:** Theory of dispersion of light; absorption bands and anomalous dispersion. Theory of Rayleigh scattering; scattering of X-rays and determination of Z of an atom.

Text Book:

[A] Optics by Brijlal & Subramanyam, Chapter-20 articles 20.1 – 20.15, 20.17 – 20.23

Reference Books:

[A] D. P. Khandelwal, Optics and Atomic Physics
[B] Text Book of Oscillations, Waves and Acoustics by Ghosh and Bhattacharya

Unit 3: Lasers:

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

[A] **Introduction;** Attenuation of light in an optical medium; Thermal Equilibrium; Interaction of light with matter; Einstein Coefficient and their relations; Light Amplification; Meeting the three requirements; Components of laser; Lasing action; Principal pumping scheme; Role of resonant cavity; Types of laser; Semiconductor laser; Laser beam characteristic; Applications

Text Book:

[A] A textbook of Optics by Dr N Subrahmanyam, Brij Lal, Dr. M N Avadhanulu, Articles 22.1, 22.2, 22.3, 22.4, 22.5, 22.6,22.7,22.8,22.9,22.10, 22.11, 22.14,22.15, 22.16

Reference Books:

[A] Lasers Theory and Applications by Thyagrajan and A K Ghatak

[B] Lasers and Nonlinear Optics by B B Laud

Unit 4: Instruments

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

[A] **Optical Instruments:** Michelson Interferometer, Fabry Perot Etalon,

[B] **Electronic Instruments:** CRO, CRT, electron gun, deflecting plates, screen, methods of focusing, deflection systems, mathematical expression for electrostatic deflection sensitivity, electromagnetic deflection system, magnetic deflection in CRT, Time base (without circuits)

[B] **Transducer:** Classification of transducers, strain gauges, capacitive transducer, variable differential transformer transducer, piezoelectric transducer, photosensitive devices

Text Book:

[A] Modern Electronic Instrumentation and Measurement Techniques, Albert D. Helfrick, William D. Cooper, Article :-11.1, 11.3, 11.4.1, 11.4.3, 11.4.5, 11.6

Reference Books:

[A] Electronic & Radio Engineering by M. L. Gupta

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

DEPARTMENT OF PHYSICS & ELECTRONICS

Major Course: Physics and Experiential Lab-III

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		
PHMC333L: **Physics and Experiential Lab-III**	4	8		10 + 2 from a recognized board	Science Stream Math-Group

LEARNING OBJECTIVES (LO)
(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 properties of matter such as the determination of moduli of elasticity viz.,young's modulus and determine charge of electron by Thomson's method.

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

Course Outcomes (CO)

(Physics Laboratory)

CO 1	The course objectives include: understanding measurement techniques.
CO 2	Demonstrating knowledge of experimental physics concepts, constructing and analyzing circuits,
CO 3	Estimating errors, and relating textbook physics to real-world observations
CO 4	To bridge the gap between theory and experiment.

(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 -III PHMC333L (Practical)

01	Absorption coefficient of liquids /Glass
02	Young’s modulus by Koening’s Method
03	Wavelength of prominent spectral lines of mercury by diffraction grating
04	Diffraction by single slit
05	Resolving power of telescope
06	Resonance Pendulum
07	Figure of merit of Ballistic Galvanometer
08	To determine Radius of curvature of convex lens by Newton’s rings method
09	h – parameters of CE transistor
10	Fixed bias and potential divider bias
11	e/k by power transistor
12	L by Maxwell’s bridge.
13	e/m by Thomson’s method
14	Polarization by Brewster's law