गोंय विद्यापीठ
ताळगांव पठार,
गोंय –४०३ २०६
फोन : +९१–८६६९६०९०४८

(Accredited by NAAC)

ATMANIRBHAR BHARAT
SWAYAMPURNA GOA

Goa University
Taleigao Plateau, Goa-403 206
Tel : +91-8669609048
Email : registrar@unigoa.ac.in
Website : www.unigoa.ac.in

GU/Acad –PG/BoS -NEP/2025-26/174 Date: 26.06.2025

CIRCULAR

The Academic Council & Executive Council of the University has approved Ordinance OA-35A relating to PG Programmes offered at the University campus and its affiliated Colleges based on UGC 'Curriculum and Credit Framework for Postgraduate Programmes'. Accordingly, the University has proposed introduction of Ordinance OA-35A from the Academic year 2025-2026 onwards.

The Programme structure and syllabus of Semester I and II of the **Master of Science in Physics** Programme approved by the Academic Council in its meeting held on 13th & 14th June 2025 is attached.

The Dean & Vice-Dean (Academic) of the School of Physical and Applied Sciences are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2025.06.26 15:37:31 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,
1. The Dean, School of Physical and Applied Sciences, Goa University.
2. The Vice-Dean (Academic), School of Physical and Applied Sciences, Goa University.

Copy to:
1. Chairperson, BoS in Physics, Goa University.
2. Programme Director, M.Sc. Physics, Goa University.
3. Controller of Examinations, Goa University.
4. Assistant Registrar Examinations (PG), Goa University.
5. Director, Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

GOA UNIVERSITY

MASTER OF SCIENCE IN PHYSICS

(Effective from the Academic Year 2025-26)

ABOUT THE PROGRAMME
The School of Physical and Applied Sciences (SPAS) offers a two-year (4-semester) Master's program, with an annual intake of 50 students. It continuously reinvents its teaching orientation and syllabi contents, taking into account contemporary requirements to introduce courses, particularly in applied, vocational and interdisciplinary areas. M. Sc. programme comes with three specializations; Solid State Physics, Computational Physics and Biophysics which students are required to select in the third semester. Advanced papers have been designed to acquaint students and provide them with a broader perspective.

OBJECTIVES OF THE PROGRAMME
To provide students with advanced knowledge in fundamental and advanced physics concepts, develop strong analytical and problem-solving skills, enhance practical skills through laboratory experience, and equip students with computer-aided investigation skills. Additionally, the program aims to foster an understanding of interdisciplinary science and prepare students for professional development or further research.

Approved by: Academic Council on 13th & 14th June 2025

PROGRAMME SPECIFIC OUTCOMES (PSO)	
PSO 1.	**Gain knowledge** of classical and quantum mechanical approaches, their realm and applicability to nuclear, atomic and condensed systems or astronomical systems.
PSO 2.	**Demonstrate** proficiency in mathematics and the mathematical concepts needed for a proper understanding of physics
PSO 3.	**Understand** the theorems and circuits in electronics and use them in various applications
PSO 4.	**Gain hands on experience** in designing, constructing experiments, experimental circuits and setups and measurement of physical quantities and estimating associated errors.
PSO 5.	**Understand and analyse** the structural, electrical, thermal, magnetic and optical properties of solids
PSO 6.	**Apply** advanced numerical techniques and computer programming to solve complex problems in physics.
PSO 7.	**Apply** concepts of physics in understanding biological processes and various methods in Biophysical analysis.
PSO 8.	**Develop** an appreciation of experimental and theoretical techniques used to infer the nature of different physical systems
PSO 9.	Use the tools, methodologies, language and conventions of physics to test and communicate ideas and explanations

PROGRAMME STRUCTURE

Master of Science in Physics

Effective from Academic Year 2025-26

Bridge Course			
Sr. No.	**Course Code**	**Title of the Course**	**Credits (Theory + Practical)**
1	PHY-1000	Bridge Course in Mathematical Methods	2+0=2
2	PHY-1001	Bridge Course in Thermal Physics	2+0=2
3	PHY-1002	Bridge Course in Optics	2+0=2
4	PHY-1003	Bridge Course in Quantum Mechanics	2+0=2
5	PHY-1004	Bridge Course in Electrostatics and Magnetostatics	2+0=2
6	PHY-1005	Introduction to Biology and Biophysics	2+0=2

SEMESTER I				
Discipline Specific Core (DSC) Courses (16 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits (T+P)**	**Level**
1	PHY-5000	Mathematical Methods of Physics	4+0=4	400
2	PHY-5001	Classical Mechanics	4+0=4	400
3	PHY-5002	Electromagnetic Theory	4+0=4	400
4	PHY-5003	Electronics	4+0=4	400
		Total Credits for DSC Courses in Semester I	**16**	
Discipline Specific Elective (DSE) Course (4 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits (T+P)**	**Level**
1	PHY-5201	Electronics and Computer Programming in Fortran/C/Python Practical	0+4=4	400
2	PHY-5202	Design and Fabrication Practical - I	0+4=4	400
		Total Credits for DSE Courses in Semester I	**4**	
		Total Credits in Semester I	**20**	

SEMESTER II				
Discipline Specific Core (DSC) Courses				
Sr. No.	**Course Code**	**Title of the Course**	**Credits (T+P)**	**Level**
1	PHY-5004	Quantum Mechanics	4+0=4	500
2	PHY-5005	Statistical Mechanics	4+0=4	500
3	PHY-5006	Nuclear and Elementary Particle Physics	4+0=4	500
4	PHY-5007	Atomic Physics	4+0=4	500
Total Credits for DSC Courses in Semester II			**16**	
Discipline Specific Elective (DSE) Courses (4 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits (T+P)**	**Level**
1	PHY-5203	General Physics Practical	0+4=4	400
2	PHY-5204	Design and Fabrication Practical - II	0+4=4	400
Total Credits for DSE Courses in Semester II			**4**	
Total Credits in Semester II			**20**	

Blooms Taxonomy Cognitive Levels	
Cognitive Level	**Notations**
K1	Remembering
K2	Understanding
K3	Applying
K4	Analyzing
K5	Evaluating
K6	Create

BRIDGE COURSES

Title of the Course	Bridge Course in Mathematical Methods
Course Code	PHY-1000
Number of Credits	2
Theory/Practical	Theory
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	Yes
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course develops problem solving capabilities of students. It also helps to revise and understand the concepts based on Integration, differentiation and such other basic topics of mathematics, which are useful in solving problems based on Physics.	
Course Outcomes:	Students able to	**Mapped to PSO**
	CO 1. Understand differentiation, partial differentiation, integration and Ordinary differential equations	PSO2
	CO 2. Apply the above techniques to solve the problems in physics.	PSO2
	CO 3. Understand concepts of vector algebra, limits and series.	PSO2
	CO 4. Apply these techniques for solving the problems in physics and day to day life	PSO2

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**Preliminary Calculus** Differentiation from first principles; products; the chain rule; quotients; implicit differentiation; logarithmic differentiation; Leibnitz' theorem; special points of a function; theorems of differentiation, Integration from first principles; the inverse of differentiation; integration by inspection; sinusoidal functions; logarithmic integration; integration using partial fractions; substitution method; integration by parts; reduction formulae; infinite improper integrals; plane polar coordinates; integral inequalities; applications of integration.	**10**	CO1, CO2	K2, K3
Module 2:	**Partial Differentiation** Definition of partial derivative; the total differential and total derivative; Exact and inexact differentials; Useful theorems of partial differentiation; the chain rule; Change of variables; Taylor's theorem for many variable functions; Stationary values of many variable functions; Stationary variables under constraints; Thermodynamic relations; Differentiation of integrals.	**5**	CO1, CO2	K2, K3
Module 3:	**Series and Limits** Series; Summation of series (arithmetic, geometric); convergence of infinite series; Operations with series; Power series; Taylor series; Evaluation of limits.	**5**	CO1, CO2	K2, K3
Module 4:	**Vector Algebra** Scalars and vectors; Addition and subtraction of vectors; Multiplication by a scalar; Basis vectors and components; Magnitude of a vector; Multiplication of vectors; Equation of lines and planes; Using vectors to find distances; Reciprocal vectors.	**5**	CO3, CO4	K2, K3
Module 5:	**Ordinary differential equations** Linear equations with constant coefficients; Linear equations with variable coefficients; General ordinary differential equations.	**5**	CO3, CO4,	K2, K3
Pedagogy:	Lectures/ tutorials or a combination of these. Sessions shall be interactive in nature to enable peer group learning.			

Texts:	1. K.F. Riley, M.P. Hobson and S.J. Bence, Mathematical Methods for Physics and engineering, Cambridge University Press, Cambridge UK (Reprint 2002). 2. George B. Arfken and Hans J. Weber, Mathematical methods for Physicists, 7/e Elsevier Inc., 2012. 3. Mathematics text books of XI and XII Science prescribed by NTSE/CBSE/Goa Board.

Title of the Course	Bridge Course in Thermal Physics
Course Code	PHY-1001
Number of Credits	2
Theory/Practical	Theory
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	Yes
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	This course aims to introduce basic concepts of thermodynamics, laws of thermodynamics, entropy its applications.			
Course Outcomes:	Students able to		**Mapped to PSO**	
	CO 1. Describe basic concepts of thermodynamics		PSO1	
	CO 2. Understand thermodynamic properties of pure substances		PSO1	
	CO 3. Formulate and apply the first and second laws of thermodynamics		PSO1	
	CO 4. Understand concepts of entropy and the third law of thermodynamics.		PSO1	
	CO 5. Understand thermodynamic potentials and their relations.		PSO1	
Content:		**No of**	**Mapped**	**Cognitive**

		hours	to CO	Level
Module 1:	**Zeroth and First Law of Thermodynamics: Extensive and intensive** Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.	**6**	CO1, CO2	K1, K2
Module 2:	**Second Law of Thermodynamics:** Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.	**8**	CO1, CO3	K1, K2, K3
Module 3:	**Entropy:** Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. The entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. The unattainability of Absolute Zero.	**6**	CO1, CO4	K1, K2
Module 4:	**Thermodynamic Potentials:** Extensive and Intensive Thermodynamic Variables. Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties, and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic	**5**	CO1, CO5	K1, K2

	demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations..			
Module 5:	**Maxwell's Thermodynamic Relations:** Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of Cp-Cv, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process	**5**	CO1, CO5	K1, K2
Pedagogy:	Lectures/ tutorials or a combination of these. Sessions shall be interactive in nature to enable peer group learning.			
Texts:	1. M.W. Zemansky, Richard Dittman, Heat and Thermodynamics, McGraw-Hill, (1981). 2. Meghnad Saha, and B.N.Srivastava, A Treatise on Heat, Indian Press (1958) 3. S. Garg, R. Bansal and Ghosh, Thermal Physics, 2nd Edition, Tata McGraw-Hill (1993). 4. Carl S. Helrich, Modern Thermodynamics with Statistical Mechanics, Springer (2009). 5. Sears & Salinger, Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Narosa. (1988) 6. S.J. Blundell and K.M. Blundell, Concepts in Thermal Physics, 2nd Ed., Oxford University Press (2012).			

Title of the Course	Bridge Course in Optics
Course Code	PHY-1002
Number of Credits	2
Theory/Practical	Theory
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	Yes
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	This course aims to understand the various concepts of geometric and wave optics			
Course Outcomes:	Students able to		**Mapped to PSO**	
	CO 1. Understand geometrical and wave optics		PSO1	
	CO 2. Understand phenomena of interference and diffraction		PSO1	
	CO 3. Apply these phenomena to problems in Physics		PSO1	
	CO 4. Understand concept of polarization of light.		PSO1	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**

Module 1:	**Geometric Optics** Brief history, Propagation of light, Scattering, Reflection and Refraction of light, Fermat's principle, Ray equations, Refraction and reflection by spherical surfaces, Paraxial optics, lenses, mirrors, prisms, optical systems, Total internal reflection, thick lenses, Aberrations. Introduction to eyepieces, Ramsden and Huygens eyepieces.	**6**	CO1	K2
Module 2:	**Wave Optics** Simple harmonic motion, vibrations, origin of refractive index, sinusoidal waves, one-dimensional wave equation, transverse and longitudinal vibrations, Huygen's principle, plane waves, spherical and cylindrical waves.	**6**	CO1	K2
Module 3:	**Interference** Superposition of Waves, Division of wavefront & division of amplitude, Formation of colors in thin film- reflected system, transmitted system, wedge shaped film, Newton's Rings and its application to determine refractive index of liquid (Normal Incidence only), Interferometry: Michelson interferometer-its principle, working and its application to determine wavelength and difference between two wavelengths, Coherence.	**6**	CO2, CO3	K2, K3
Module 4:	**Diffraction** Fraunhofer diffraction, Single slit and Double slit patterns, Limit of resolution, Diffraction grating, Fresnel diffraction, zone-plates, Diffraction by circular discs and apertures, Holography.	**6**	CO2, CO3	K2, K3
Module 5:	**Polarization of light** Nature of polarized light, Dichroism, Birefringence, Scattering and Polarization, Polarization by reflection, Brewster angle, Circular polarizers, Wave plates.	**6**	CO3, CO4	K2, K3
Pedagogy:	Lectures/ tutorials or a combination of these. Sessions shall be interactive in nature to enable peer group learning.			
Texts:	1. Ajoy Ghatak, Optics, 7th Edition, Tata-McGraw-Hill (2020). 2. Eugene Hecht, Optics, Pearson, 5th Edition, (2019).			

	3. Brij Lal, M N Avadhanulu & N Subrahmanyam, A Textbook of Optics, 25th edition, S. Chand & Company (2012). 4. F.A. Jenkins and H.E. White, Fundamental of Optics, Tata McGraw-Hill (1981).

Title of the Course	Bridge Course in Quantum Mechanics
Course Code	PHY-1003
Number of Credits	2
Theory/Practical	Theory
Level	
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	Yes
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course aims to understand the various phenomena of early quantum physics and develop the essential ideas of the old quantum theory.	
Course Outcomes:	Students able to	**Mapped to PSO**
	CO 1. Understand the concept of the wave-particle duality of radiation and particles.	PSO1
	CO 2. Understand energy quantization.	PSO1
	CO 3. Understand quantization of angular momentum.	PSO1
	CO 4. Describe the structure of the hydrogen atom.	PSO1
	CO 5. Apply wave mechanics to one dimension problems	PSO1

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**Thermal Radiation and Planck's Postulate** Thermal Radiation, Classical Theory of Cavity Radiation, Planck's Theory of Cavity Radiation, Planck's Postulate and Its Implications.	**3**	CO1	K2
Module 2:	**Photons—Particle-like Properties of Radiation** Introduction, The Photoelectric Effect, Einstein's Quantum Theory of the Photoelectric Effect, The Compton Effect, The Dual Nature of Electromagnetic Radiation.	**2**	CO1	K2
Module 3:	**de Droglie's Postulate—Wave-like Properties of Particles** Matter Waves, The Wave-Particle Duality, The Uncertainty Principle, Properties of Matter Waves, Some Consequences of the Uncertainty Principle, The Philosophy of Quantum Theory	**2**	CO1	K2
Module 4:	**Bohr's Model of the Atom** Thomson's Model, Rutherford's Model, The Stability of the Nuclear Atom, Atomic Spectra, Bohr's Postulates, Bohr's Model, Atomic Energy States.	**3**	CO1, CO2, CO3, CO4	K1, K2
Module 5:	**Schroedinger's Theory of Quantum Mechanics** Introduction, Plausibility Argument Leading to Schrödinger's Equation, Born's Interpretation of Wave Functions, Expectation Values, the time-independent Schrödinger Equation, Required Properties of Eigen functions, Energy Quantization in the Schrodinger Theory.	**5**	CO2, CO3, CO5	K1, K2
Module 6:	**Solutions of Time-Independent Schrodinger Equations** Introduction, The Zero Potential, The Step Potential (Energy Less Than Step Height), The Step Potential (Energy Greater Than Step Height), The Barrier Potential, Examples of Barrier Penetration by Particles, The Square Well Potential, The Infinite Square Well Potential, The Simple Harmonic Oscillator Potential	**15**	CO5	K3

Pedagogy:	Lectures/ tutorials or a combination of these. Sessions shall be interactive in nature to enable peer group learning.
Texts:	1. Robert Eisberg and Robert Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, John Wiley & Sons (2006) 2. A. Ghatak and S. Lokanathan, Quantum Mechanics, Theory and Applications, Mc Millan (2004). 3. P. M. Mathews, and K. Venkatesan, A Textbook of Quantum Mechanics, 2nd Ed., McGraw Hill (2010) 4. Leonard I. Schiff, Quantum Mechanics, 3rd Edn. Tata McGraw Hill, (2010)

Title of the Course	Bridge Course in Electrostatics and Magnetostatics
Course Code	PHY-1004
Number of Credits	2
Theory/Practical	Theory
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	Yes
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	This course is aimed at revising the electrostatics and magnetostatics			
Course Outcomes:	Students able to		**Mapped to PSO**	
	CO 1. Understand concepts like electric field, potential, electrostatic energy, dielectrics.		PSO1	
	CO 2. Apply Gauss Law to simple problems		PSO1	
	CO 3. Understand generation of magnetic field		PSO1	
	CO 4. Apply Maxwell equations		PSO1	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Electrostatics**	**15**	CO1,	K2, K3

	Coulomb's law, Electric field and potential, Gauss's law, Application of Gauss's law, the electric field in various circumstances, Electrostatic energy, dielectrics.		CO2	
Module 2:	**Magnetostatics** Electric current, the magnetic field, the magnetic force of a current, Ampere's law, magnetic field of a straight wire and of a solenoid, atomic currents, the relativity of magnetic and electric fields, the magnetic field in various situations, the vector potential, induced currents, the Maxwell equations.	**15**	CO3, CO4	K2, K3
Pedagogy:	Lectures/ tutorials or a combination of these. Sessions shall be interactive in nature to enable peer group learning.			
Texts:	1. The Feynman lectures on Physics, Vol-2, Pearson (2013) 2. Young and Freedman, University Physics with modern Physics, Pearson (2016) 3. H. C. Verma, Concepts of Physics, vol-2, Bharati Bhawan Publishers & Distributors (2019).			

Title of the Course	Introduction to Biology and Biophysics
Course Code	PHY-1005
Number of Credits	3
Theory/Practical	Theory
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	Yes
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	This is a bridge course for the students for introducing them to the concepts in biology and biophysics.			
Course Outcomes:	Students will be able to		**Mapped to PSO**	
	CO 1. Learn about biology and biochemistry		PSO1	
	CO 2. Understand the basic concepts of molecular biophysics		PSO1	
	CO 3. Gain knowledge in the structure and functioning of molecular processes		PSO1	
	CO 4. Get exposed to the recent developments in biomechanics and molecular motion.		PSO1	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction to Biology**	**5**	CO1,	K2

	Origin and evolution of life, prokaryotic cells, photosynthesis, eukaryotic cells, elementary building blocks of life		CO2, CO3, CO4	
Module 2:	**Biochemistry I** Chemical components of the cell, energy, catalysis and biosynthesis, cellular membranes, transport across membranes, energy generation in cells, cytoskeletons, cell division	**15**	CO1, CO2, CO3, CO4	K2
Module 3:	**Biochemistry II** Proteins-structure and function, DNA, RNA and chromosomes, Genes, genetics, carbohydrates, lipids and enzymes	**15**	CO1, CO2, CO3, CO4	K2
Module 4:	**Biophysics** Biological motion, free energy transduction, chemochemical machines, pumps and motors as chemochemcial machines, flux force dependence, molecular motors, mechanochemistry of molecular motors, biomolecular forces, biomechanics of muscle contraction and cardiovascular system.	**10**	CO1, CO2, CO3, CO4	K2
Pedagogy:	Lectures/ tutorials or a combination of these. Sessions shall be interactive in nature to enable peer group learning.			
Texts:	1. Geoffrey M. Cooper and Robert E. Hausman, The Cell: A Molecular Approach, Seventh Edition, Oxford University Press (2018). 2. Dennis Bray, Karen Hopkin, Alexander D. Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter, Essential Cell Biology, Bruce Alberts, Fourth Edition Garland Science (2013). 3. David Clark Nanette Pazdernik Michelle McGehee, Molecular Biology, Third Edition, Elsevier (2019). 4. Jack A Tuszynski and Michal Kurzynski, Introduction to Molecular Biophysics, First Edition, CRC Press, (2003). 5. Rodney Cotterill, Biophysics: An Introduction, Wiley (2002). 6. Thomas A Weigh, Applied Biophysics, A Molecular Approach for Physical Scientist, First Edition, Wiley, (2007). 7. Mayer & Jackson, Molecular & Cellular Biophysics, Cambridge Press (2006).			

SEMESTER I

Discipline Specific Core Courses

Title of the Course	Mathematical Methods of Physics
Course Code	PHY-5000
Number of Credits	4
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	Prepare the students with necessary mathematical skills that are essential to understand different phenomena in physics. The course also helps students to understand the theoretical background of other core courses in physics.	
Course Outcomes:	Students able to	**Mapped to PSO**
	CO 1. Solve ordinary differential equations using different methods.	PSO2
	CO 2. Understand basics of complex variables, vector space and integral transforms.	PSO2
	CO 3. Solve wave equation and heart conduction problems	PSO2

	CO 4. Demonstrate proficiency in mathematical skills required for a master's in Physics.		PSO2	
	CO 5. Apply the mathematical skills in other courses of Physics.		PSO2	
	CO 6. Evaluate the mathematical background of various concepts in physics.		PSO2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Ordinary Differential Equations** Second order homogeneous and inhomogeneous equation, Wronskian, General Solutions, Ordinary and Singular points, Series Solutions. Polynomial solutions, Legendre's equation, Bessel's equation, Gamma function	**14**	CO1, CO4, CO5, CO6	K2, K3, K4,K5
Module 2:	**Functions of Complex Variable** Limits, Continuity, Analyticity of Functions of a Complex Variable, Taylor and Laurent Series, Isolated and Essential Singularities, Branch Cuts, Cauchy Formula, Contour Integration, Application of Residue Theorem.	**14**	CO2, CO4, CO5, CO6	K2, K3, K4,K5
Module 3:	**Linear Vector Spaces** Linear Operators, Matrices, Coordinate Transformations, Eigenvalue Problems, Diagonalization of Matrices, Infinite Dimensional Spaces, Elements of Group Theory.	**10**	CO2, CO4, CO5, CO6	K2, K3, K4,K5
Module 4:	**Integral Transforms** Fourier Series, Fourier Transforms, Laplace Transforms, Applications of Integral Transforms.	**12**	CO2, CO4, CO5, CO6	K2, K3, K4,K5
Module 5:	**Boundary Value and Initial Value Problems** Vibrating String in one Dimension, Heat Conduction, and Wave Equation.	**10**	CO3, CO4, CO5, CO6	K2, K3, K4,K5
Pedagogy:	Lectures/ tutorials or a combination of these. Sessions shall be interactive in nature to enable peer group learning.			
Texts:	1. George B. Arfken and Hans J. Weber, Mathematical methods for Physicists, 7/e Elsevier Inc., (2012). 2. K.F. Riley, M.P. Hobson and S.J. Bence, Mathematical Methods for Physics and engineering, Cambridge University Press, Cambridge UK (Reprint 2002)			

	3. J. Mathew and R. L. Walker, Mathematical Methods for Physics, Benjamin Publishers (1973). 4. James W. Brown and R. V. Churchill Complex Variables and Applications, 6th Edition (international), McGraw - Hill (1996). 5. L. A. Pipes, Applied Mathematics for Engineers and Physicists, 3rd Edition, McGraw-Hill (1971). 6. W. W. Bell, Special Functions for Scientists and Engineers, D. Van Nostrand Company Ltd (2004). 7. Charlie Harper, Introduction to Mathematical Physics, PHI. 8. Murray R. Spiegel, Theory and problems in Complex Variables by (Schaum' series) (2009). 9. Murray R. Spiegel, Theory and problems of advanced Mathematics for Engineers and Scientists by (Schaum's series) (1980).
Web Resources:	1. https://nptel.ac.in/courses/115103036 2. https://archive.nptel.ac.in/courses/115/105/115105097/ 3. https://nptel.ac.in/courses/115106086

Title of the Course	Classical Mechanics
Course Code	PHY-5001
Number of Credits	4
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course is aimed at understanding intermediate to advanced classical mechanics and to build the necessary framework for other topics that requires classical mechanics such as quantum mechanics, statistical mechanics and electromagnetism.	
Course Outcomes:	Students will be able to	**Mapped to PSO**
	CO 1. Understand and apply the principles of Lagrange-Hamilton formalism to classify and explain the motion of a mechanical system.	PSO 1
	CO 2. Analyze equations of motion for complex mechanical systems in classical mechanics by applying the formalism of Lagrangian and Hamiltonian.	PSO 1
	CO 3. Analyze the differential equations of orbit and determine the stability of the orbit under central force.	PSO 1

	CO 4. Evaluate and contrast the differences between Lagrangian and Hamiltonian formalism, Galilean and Lorentz transformation, and various reference frames.		PSO 1	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Newton's Laws of Motion:** Mechanics of a single particle, Mechanics of a system particles, Constraints and their classification, Principle of virtual work, D'Alembert's principle.	**6**	CO1	K2, K3
Module 2:	**Lagrangian Formulation:** Degrees of Freedom, Generalized Coordinates, Calculus of variations, Hamilton's principle, Euler-Lagrange's equations of motion, Application to non-holonomic systems, Advantages of a variational principle formulation, Conservation theorems and symmetry properties.	**10**	CO1, CO2	K2, K3, K4
Module 3:	**Rigid Body Dynamics:** Eulerian angles, Inertia tensor, Angular momentum of rigid body. Free motion of rigid body, Motion of symmetric top.	**8**	CO1, CO2	K2, K3, K4
Module 4:	**Hamilton's equation of motion:** Legendre transformation and the Hamilton equations of motion, cyclic coordinates and conservation theorems, Routh's procedure and oscillation about steady motion, Derivation of Hamilton's equations from a variational principle, Principle of least action.	**10**	CO1, CO2, CO4	K2, K3, K4, K5
Module 5:	**Canonical Transformations:** Equations of canonical transformations, Examples of canonical transformations, Poisson brackets and other canonical invariants, Equations of motion, Infinitesimal canonical transformation theorems in Poisson bracket formulation, Angular momentum, Poisson brackets relations, Lagrange brackets.	**8**	CO1, CO2, CO4	K2, K3, K5
Module 6:	**Hamilton - Jacobi Theory:** H-J equation for Hamilton's principal function, Harmonic oscillator problems, H -J equation for characteristic function, Action angle, Kepler's problem.	**6**	CO1, CO2, CO3	K2, K3, K4
Module 7:	**Two-body Central Force Problem:** Equations of motion and first integrals, Classification of orbits, virial theorem, Differential equation and integrable power law potentials, Kepler's problem.	**7**	CO1, CO3	K2, K3, K4

Module 8:	**Small Oscillations:** Simple Harmonic Oscillations, Damped Oscillations, Forced Oscillations without and with damping, Coupled Oscillations.	**5**	CO1, CO2	K2, K3, K4
Pedagogy:	Lectures/ tutorials/ assignments. Sessions shall be interactive in nature to enable peer group learning.			
Texts:	1. H. Goldstein, Classical Mechanics. McMillan, Bombay, (1998). 2. J. C. Upadhyaya, Classical Mechanics. Himalaya, Publishing House, Mumbai, (1991). 3. M. G. Calkin, Lagrangian and Hamiltonian Mechanics. World Scientific, (1996). 4. N. C. Rana, and P. S. Joag, Classical Mechanics. Tata McGraw-Hill, (1991). 5. P. V. Panat, Classical Mechanics. Alpha Science International Ltd, (2004).			

Title of the Course	Electromagnetic Theory
Course Code	PHY-5002
Number of Credits	4
Theory/Practical	Theory
Level	400
Effective from AY	Academic year 2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• The aim of this course is to develop understanding of time varying scalar and vector electromagnetic fields and relativity. • To inculcate fundamental concepts related to electromagnetic waves, their transmission via wave guides, radiation and plasma.	
Course Outcomes:	Students will be able to	**Mapped to PSO**
	CO 1. **Analyze** the nature of electromagnetic fields due to time varying charge and current distribution using Maxwell's equations.	PSO1, PSO 2
	CO 2. **Interpret** the properties of plane waves in unbounded space, and understand such concepts as wavelength, phase velocity, and attenuation	PSO1, PSO 2

	CO 3. **Understand** fundamental concepts of plasma systems using the concepts of electromagnetic theory		PSO1, PSO 2	
	CO 4. **Apply** equations of electromagnetism to the analysis of waveguides		PSO1, PSO 2	
	CO 5. **Understand** the principles of relativistic electrodynamics.		PSO1, PSO 2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Maxwell's Equations:** Displacement current, Maxwell's equations, Vector and Scalar potentials, Gauge transformation, Lorentz and Coulomb gauge, Poynting's theorem, Conservation of energy and momentum for charged particles and fields.	**10**	CO1	K4
Module 2:	**Electromagnetic Waves** Plane electromagnetic waves and their propagation in non- conducting and conducting media, Frequency dispersion in conductors	**09**	CO2	K2
Module 3:	**Electromagnetic Radiation** Retarded Potentials, Fields and radiation by localized dipole, Lienerd Weichert potentials, Power radiated by an accelerated charge.	**10**	CO2	K2
Module 4:	**Physics of Plasmas** Electrical neutrality in a plasma, Particle orbits and drift motion in a plasma, Magnetic mirrors, The hydro- magnetic equations, The pinch effect, Plasma oscillations and wave motion, Reflection from a plasma (ionosphere).	**09**	CO3	K2, K3
Module 5:	**Wave Guides** Propagation of Waves between conduction planes, Wave guides in arbitrary cross-section, Wave -guides in Rectangular Cross-section, Coaxial Wave guide, Resonant Cavities, Dielectric wave guides.	**10**	CO4	K3
Module 6:	**Relativistic Electrodynamics** Lorentz transformation as four dimensional orthogonal transformation, Lorentz	**12**	CO5	K2

	matrix, four vectors in mechanics and electrodynamics, Lorentz covariance of Maxwell equations, field tensor, transformation of fields, field due to a point charge in uniform motion.			
Pedagogy:	Lectures/ tutorials/ assignments. Sessions shall be interactive in nature to enable peer group learning.			
Texts:	1. J. B. Marion, Classical Electromagnetic Radiation, Academic Press, New York (1980). (Second edition) 2. J. R. Reitz and F. J. Milford, Foundations of Electromagnetic theory, Addison – Welsey, Reading (1960). (Third Edition) 3. B. B. Laud, Electromagnetics, Wiley Eastern Ltd., New Delhi (1983). (Third Edition)			
References/ Readings:	1. J. D. Jackson, Classical Electrodynamics, Wiley, New York (1995). (Third Edition) 2. W. H. Panofsky and M. Philips, Classical Electricity and Magnetism, Addison-Wesley Publication, 1962. (Second Edition) 3. David J. Griffiths, Introduction to Electrodynamics, Prentice - Hall of India Pvt. Ltd., New Delhi (1995). (Fourth Edition) 4. S. P. Puri, Classical Electrodynamics, Tata McGraw-FEII Publishing Co. Ltd. New Delhi (1997).			
Web Resources:	NPTEL- Electromagnetic Waves in Guided and Wireless Media https://nptel.ac.in/courses/108104130			

Title of the Course	Electronics
Course Code	PHY-5003
Number of Credits	4
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	The objective of the course is to • Introduce students to wide range of electronic circuits and their applications in solving different problems of day to day to life and physics. For Ex. Using OP-AMPs. • To give basic understanding of opto-electronic devices, modulation, signals, microprocessor and memories.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand the principles and circuits in electronics and use them in various applications.	PSO3
	CO 2. Acquire knowledge about working principles of opto-electronic devices and communication electronics.	PSO3
	CO 3. Get exposure to microprocessor and memory devices.	PSO3

	CO 4. Be able to analyze process of AM and FM communication.		PSO3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**OP-AMP Applications** 1.1. OP-AMPS with negative feedback, 1.2. Voltage controlled voltage source (VCVS), Current controlled voltage source (ICVS), Voltage controlled current source (VCIS), Current controlled current source (ICIS), 1.3. Inverting and noninverting amplifier circuits, 1.4. Open-loop frequency and phase response, Closed-loop frequency response, 1.5. Differential amplifier, Instrumentation amplifier, DC and AC amplifiers, 1.6. Summing, scaling and averaging amplifier, 1.7. Voltage to current converter, Current to voltage converter.	**15**	CO1	K2
Module 2:	**Opto-electronic devices** 2.1. Radiative and non-radiative transitions, Characteristics of LED, Photoconductor, 2.2. Photo diode, Photo transistor, Photo detector, 2.3. Solar cell, 2.4. Semiconductor laser; 2.5. Optical fiber, Optical fiber waveguides, 2.6. Fundamentals of optical communication	**15**	CO1, CO2	K2, K3
Module 3:	**Communication Electronics** 3.1. Analog and digital signals, 3.2. Modulation, Types of modulation, Basic principles of amplitude, frequency and phase modulation, 3.3. Simple circuits for amplitude modulation and demodulation, 3.4. Digital modulation and demodulation, 3.5. Microwave Oscillators, 3.6. Cavity resonators, 3.7. Standing wave detector.	**15**	CO2, CO4	K2, K4

Module 4:	**Digital Electronics** 4.1. Types of signals, A/D and D/A conversion methods; 4.2. Digital signal processing (DSP) basics, DSP applications; 4.3. Introduction to Microprocessors, Elements of 8-bit Microprocessors (INTEL \ 8085) 4.4. Memory and storage, RAM, ROM, PROM and EPROM, Flash memories, 4.5. Magnetic and optical storage.	**15**	CO1, CO3	K2, K3
Pedagogy:	Lectures/tutorials/assignments. Sessions shall be interactive in nature to enable peer group learning.			
Texts:	1. Millman, J., Halkias, C., Parikh C., Integrated Electronics, Analog and Digital Circuits and Systems, McGraw – Hill Education, 2nd Edition (2018) 2. Kennedy, G., Electronics Communication Systems, IV Edn, Tata McGraw-Hill Book Co. New Delhi (2003). 3. Chen, Chin-Lin, Elements of Optoelectronics and Fiber Optics, McGraw-Hill Book Co. New Delhi (2014).			
References/ Readings:	1. Boylestad, R. L. and Nashelsky L., Electronic Devices & Circuit Theory, XI Edn. Prentice-Hall of India (2015). 2. Floyd, T. L., Electronic Devices, V Edn. Pearson Education Asia (2001). 3. Gayakwad, R, A., Op-Amps and Linear Integrated Circuits, IV Edn. Prentice-Hall of India (2002). 4. Shrader, R., Electronic Communication, Glencoe Division of MacMillan (1993).			

Discipline Specific Elective Courses

Title of the Course	Electronics and Computer Programming in Fortran/C/Python Practical
Course Code	PHY-5201
Number of Credits	4
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course offers laboratory training • in the design and construction of electronic circuits commonly used in physics experiments, • in computer programming using one of the three languages (Fortran / C /Python), with an emphasis on solving simple scientific problems	
Course Outcomes:	Student will be able to	**Mapped to PSO**
	CO 1. Design and construct electronic circuits by identifying and fetching different components.	PSO4
	CO 2. Record observations from different measuring instruments, plot graphs and analyze the results.	PSO4

	CO 3. Demonstrate the ability to maintain a laboratory notebook.		PSO4	
	CO 4. Understand fundamental programming concepts such as variables, data types, control structures, functions, and arrays		PSO6	
	CO 5. Write and debug simple programs using a high-level programming language such as Fortran/C/Python		PSO6	
	CO 6. Apply logical thinking and problem-solving techniques to develop algorithms for basic computational problems		PSO6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Experiments are to be performed on following topics (minimum 8) with emphasis on designing and constructing the circuit on a bread board. 1. Operational Amplifier parameters 2. Design and Construction of Wien Bridge Oscillator 3. Design and Construction of phase shift oscillator 4. Design and Construction of Astable Multivibrator 5. Design and Construction of Monostable Multivibrator 6. Schmitt Trigger circuit and its use as a zero crossing detector and squaring circuit 7. Voltage Regulator 8. Constant Current Source 9. Design and Construction of DC differential amplifier using op-amps 10. Design and Construction of Function generator 11. Design and construction of Negative nonlinear resistor 12. J. K. flip-flop counter: Scale of 16 and 10 using IC 13. Adder and Subtractor Circuits	**60**	CO1, C02, CO3	K3, K4, K5, K6
Module 2:	**Fundamentals of Computer Programming** Introduction to computers, Introduction to programming languages, Writing,	**15**	CO4, CO5	K2, K3

	compiling/interpreting, and executing programs, Error diagnostics, Variables, constants, and data types, Input and output operations, Operators and expression evaluation, Practical exercise			
Module 3:	**Logical Operations and Control Constructs** Logical expressions and operators, conditional operators, Branching statements, Looping statements, Nested control statements, Practical exercise	**15**	CO4, CO5, CO6	K2, K3, K5
Module 4:	**Procedures** Program Units, Introduction to Procedures, Intrinsic Procedures, User defined procedures, accessing procedures, passing arguments to procedures, Practical Exercise	**15**	CO4, CO5, CO6	K2, K3, K5
Module 5:	**Arrays and Data Handling** Defining an array, processing an array, passing arrays to procedures, multidimensional arrays, file handling, Practical Exercise	**15**	CO4, CO5, CO6	K2, K3, K5
Pedagogy:	Laboratory Experiments, Lectures and self-study			
References/ Readings:	1. D. P. Leach, A. P. Malvino and G. Saha, Digital Principles and Applications. Tata Mc Graw Hill 7e, (2011). 2. J. Millman and C. C. Halkias, Integrated Electronics: Analog and Digital Circuits and Systems. McGraw Hill International Student Ed., (1972). 3. LM317 – 3 Terminal Adjustable Voltage regulator datasheet Rev. X, Texas Instruments 4. V. Rajaraman, Computer Programming in FORTRAN 90 and 95, Prentice-Hall of India, New Delhi (1999). 5. Martin Counihan, Fortran 95, UCL Press Limited University College London (1996). 6. Stephen Chapman, Fortran 95/2003: for Scientists and Engineers, McGraw-Hill (2007). 7. Byron Gottfried, Programming with C, Tata McGraw- Hill (1996). 8. David Beazley and Brian K. Jone, Python Cookbook: Recipes for Mastering Python 3, O'Reilly Media (2013) 9. Martin C. Brown, Python: The Complete Reference, McGraw Hill (2018)			

Title of the Course	Design and Fabrication Practical - I
Course Code	PHY-5202
Number of Credits	4
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To develop interest and skill for designing and building laboratory equipment commonly used in Physics Laboratory	
Course Outcomes:	Student will be able to	**Mapped to PSO**
	CO 1. Understand the working of simple electronic equipment used in a Physics Laboratory.	PSO3, PSO4
	CO 2. Design and build simple electronic equipment used in Physics Laboratory.	PSO3, PSO4
	CO 3. Evaluate and rectify faults in simple electronic equipment used in Physics Laboratory.	PSO3, PSO4

	CO 4. Compare and contrast the performance of a commercial and their built equipment.		PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Design and construct a Constant current source (100 µA – 100 mA), evaluate its performance and make it work and pack it in a box. Compare its performance with a commercial product.	**30**	CO1, CO2, CO3, CO4	K2, K4, K5, K6
Module 2:	Design and construct a DC Differential Amplifier (with three switchable inputs and amplification of 10 and 100), evaluate its performance, make it work and pack it in a box. Compare its performance with a commercial product.	**30**	CO1, CO2, CO3, CO4	K2, K4, K5, K6
Module 3:	Design and construct a Signal Generator producing sine, square and triangle waves over 4 decades of frequency from 10 Hz – 100 KHz, evaluate its performance, make it work. Compare its performance with a commercial product.	**30**	CO1, CO2, CO3, CO4	K2, K4, K5, K6
Module 4:	Design and construct an analog Lock-in Amplifier, evaluate its performance, make it work. Compare its performance with a commercial product.	**30**	CO1, CO2, CO3, CO4	K2, K4, K5, K6
Pedagogy:	Laboratory work and Self Study			
Texts:	1. R. Srinivasan, K. R. Priolkar and T. G. Ramesh Experiments in Physics - Laboratory Manual, Indian Academy of Sciences 2017. 2. J. Millman and C. C. Halkias, Integrated Electronics: Analog and Digital Circuits and Systems, Mc Graw Hill International Student Ed. (1972).			

SEMESTER II

Discipline Specific Core Courses

Title of the Course	Quantum Mechanics
Course Code	PHY-5004
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Credited PHY-5000, PHY-5001	
Course Objectives:	• To develop foundational Concepts and Formalism of non-relativistic Quantum Mechanics. • To develop Mathematical Framework of Quantum Mechanics • To understand Schrodinger's and Heisenberg's formalism in Quantum Mechanics • To illustrate the concepts by analysing simple quantum mechanical systems	
Course Outcomes:	Student will be able to	**Mapped to PSO**
	CO 1. Understand core concepts of Quantum Mechanics	PSO1, PSO 2

	CO 2. Apply the Schrodinger equation to different systems, solve them and analyse the properties of eigenfunctions and energies		PSO1, PSO 2	
	CO 3. Explain the structure of the hydrogen atom.		PSO1, PSO 2	
	CO 4. Understand the concepts of quantization of angular momentum, spin and apply and anlyze how the addition of these quantities results.		PSO1, PSO 2	
	CO 5. Understand the concepts of approximation methods for solving Schrodinger equations and apply these methods to different systems and analyse their results.		PSO1, PSO 2	
	CO 6. Understand the fundamental scattering of quantum particles and apply it to simple systems.		PSO1, PSO 2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Schrodinger's Equation and Hermitian operators** 1.1. Time-dependent Schrodinger equation, continuity equation, expectation values, Ehrenfest's theorems, time independent Schrodinger equation and stationary states. 1.2. Hermitian operators, eigenvalues and eigenstates of Hermitian operators, momentum eigenfunctions, orthogonality and completeness of wave functions, Computability and compatibility of observables, parity operation.	**8**	CO1, CO2	K2, K3, K4
Module 2:	**The Schrodinger equation in three dimensions** Separation of the Schrodinger equation in Cartesian coordinates, Central potential, separation of the Schrodinger equation in spherical polar coordinates, The free particle, The three-dimensional square well potential, The hydrogen atom, The three-dimensional isotropic oscillator.	**12**	CO1, CO2, CO3	K2, K3, K4
Module 3:	**Vector space formulation of quantum mechanics** Dirac Notation, representation of states and observables, bra and ket vectors, linear operators, relation with wave mechanics, algebra of Hermitian operators, matrix representation, unitary operators, Schrodinger and Heisenberg	**5**	CO1, CO2	K2, K3, K4

	representations, linear harmonic oscillator problem by operator method.			
Module 4:	**Angular Momentum theory** Angular Rotations in Classical and Quantum Mechanics, Rotational Symmetry and conservation of angular momentum, Treatment of general angular momentum by operator method, eigenvalues and eigenvectors, Eigenvalues and Eigen functions of L^2 and L_z operators, ladder operators L^+ and L^-, spin angular momentum, algebra of Pauli matrices, Pauli representation of angular momentum operators. Addition of two angular momenta, spin-orbit interaction, Clebsch Gordon coefficients.	**10**	CO1, CO2, CO3, CO4	K2, K3, K4
Module 5:	**Approximation methods for stationary problems** Time-independent perturbation theory for a nondegenerate energy level, Time-independent perturbation theory for a degenerate energy level, The variational method, The WKB approximation.	**8**	CO1, CO2, CO3, CO5	K2, K3, K4
Module 6:	**Approximation methods for time-dependent problems** Time-dependent perturbation theory, General features, Time-independent perturbation, periodic perturbation, The adiabatic approximation, The sudden approximation	**7**	CO1, CO2, CO3, CO5	K2, K3, K4
Module 7:	**Quantum Collision Theory** Scattering experiments and cross-sections, potential scattering and general features, the method of partial waves, Application of the partial-wave method, the integral equation of potential scattering, The Born approximation, Collision between identical particles, Collision involving composite systems.	**10**	CO1, CO2, CO3, CO6	K2, K3, K4
Pedagogy:	Lectures / tutorials/assignments. Sessions shall be interactive in nature to enable peer group learning.			
Texts:	1. K. Ghatak and S. Lokanathan, Quantum Mechanics: Theory and Applications, Springer (2004) 2. P. M. Mathew and K. Venkatesan, A Text Book of Quantum Mechanics, 2/e, Tata McGraw Hill (2017) 3. L. I. Schiff and Jayendra Bandhyopadhyay, Quantum Mechanics, 4/e, McGraw-Hill (2017). 4. V. K. Thankappan, New Age International Publishers (2012)).			

	5. V. Devanathan, Quantum Mechanics, 2/e Narosa Publishing House (2015). 6. David J. Griffiths, Introduction to Quantum Mechanics 2/e, Cambridge India, (2016). 7. J. J. Sakurai Modern Quantum mechanics, Addition-Wesley Publishing Company, (1994). 8. R. Eisberg and R. Resnick, Quantum Physics of atoms, molecules, solids, nuclear and particles, 2/e, John Wiley and Sons, (1985). 9. W. Greiner, Introductory Quantum mechanics, Springer Publication, (2001). 10. R. L. Liboff, Introductory Quantum Mechanics, 4e, Pearson Education Ltd (2003). 11. Nouredine Zettili, Quantum Mechanics: Concepts and Applications 2/e, Wiley India (2016)

Title of the Course	Statistical Mechanics
Course Code	PHY-5005
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	PHY-5000, PHY-5001	
Course Objectives:	This course develops concepts in classical laws of thermodynamics and their application, postulates of statistical mechanics, statistical interpretation of thermodynamics, microcanonical, canonical and grand canonical ensembles; the methods of statistical mechanics are used to develop the statistics for Bose-Einstein, Fermi-Dirac and photon gases.	
Course Outcomes:	Student will be able to	**Mapped to PSO**
	CO 1. Understand the connection between statistics and thermodynamics.	PSO1
	CO 2. Analyze different ensemble theories used to explain the behaviour of statistical systems.	PSO
	CO 3. Compare classical and quantum statistics.	PSO1

	CO 4. Explain the statistical behaviour of ideal Bose and Fermi systems.		PSO1	
	CO 5. Apply techniques from statistical mechanics to a range of situations.		PSO1	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Kinetic Theory and Equilibrium state of Dilute Gas** Formulation of problem, binary collisions, Boltzmann transport equation, Boltzmann's H theorem, Maxwell- Boltzmann distribution, Method of the most probable distribution, analysis of the H theorem, recurrence and reversal paradoxes, Validity of the Boltzmann transport equation.	**12**	CO1	K2
Module 2:	**Classical Statistical Mechanics** Review of laws of thermodynamics, Entropy, Thermodynamic Potentials, Postulate of Classical Statistical Mechanics, Microcanonical ensemble, derivation of thermodynamics, equipartition theorem, Classical ideal gas, Gibbs paradox.	**12**	CO2	K4
Module 3:	**Canonical and Grand Canonical Ensembles** Canonical ensemble, energy fluctuations in canonical ensemble, grand canonical ensemble, density fluctuations in grand canonical ensembles, equivalence of canonical and grand canonical ensembles, behaviour of W(N), meaning of Maxwell construction.	**12**	CO2	K4
Module 4:	**Quantum Statistical Mechanics** Postulates of quantum statistical mechanics, density matrix, ensembles in quantum mechanics, third law of thermodynamics, ideal gases in microcanonical and grand canonical ensembles, foundations of statistical mechanics.	**8**	CO3	K2
Module 5:	**Ideal Fermi Gas** Equation of state of Ideal Fermi Gas, theory of white dwarfs, Landau diamagnetism, de Hass-Van Alphen effect, Pauli paramagnetism.	**8**	CO4, CO5	K2, K3
Module 6:	**Ideal Bose Gas** Photons, phonons, Bose-Einstein condensation.	**8**	CO4, CO5	K2, K3

Pedagogy:	Lectures / tutorials/assignments. Sessions shall be interactive in nature to enable peer group learning.
Texts:	1. Kerson Huang, Statistical Mechanics, 2/e, Wiley India (2008). 2. B. B. Laud, Fundamentals of Statistical Mechanics, New Age International Ltd. New Delhi (1998). 3. F. Reif, Fundamentals of Statistical and Thermal Physics, Waveland Press (2009). 4. L. D. Landau and E. M. Lifshitz, Statistical Mechanics, Pergamon Press (1969). 5. R. P. Feynmann, Statistical Physics, The Benjamin Cummings Publishing Co (1981). 6. S. K. Sinha, Introduction to Statistical Physics, Narosa Publishing House, New Delhi (2007). 7. Tony Guenault, Statistical Physics, New Age International Ltd. New Delhi (2007). 8. Francis W. Sears and Gerhard Salinger, Thermodynamics, Kinetic Theory, and Statistical Thermodynamics, Addison- Wesley Principles of Physics Series, (1975).

Title of the Course	Nuclear and Elementary Particle Physics
Course Code	PHY-5006
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To introduce students to the fundamental principles and concepts governing nuclear and particle physics and have a working knowledge of their application to real-life problems.	
Course Outcomes:	Student will be able to	**Mapped to PSO**
	CO 1. Understand and apply the models describing the basic nucleon and nuclear properties.	PSO1
	CO 2. Interpret the properties of strong and weak interaction.	PSO1
	CO 3. Relate the different forms of nuclear disintegration – natural and artificial, and fusion and account for their occurrence.	PSO1
	CO 4. Categorize elementary particles and nuclear states in terms of their quantum numbers.	PSO1
	CO 5. Understand elementary particle production and their detection	PSO1

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**Basic Properties of Nuclei:** a. Nuclear mass, charge, radius, binding energy, nuclear spin, and parity. b. Magnetic moments and electric quadrupole moments.	**8**	CO1	K2, K3
Module 2:	**Two-Body Problem:** a. Brief review of quantum mechanics tools, properties of deuteron, theory of the ground state of deuteron, magnetic moment, and electric quadrupole moment of deuteron. b. Theory of nucleon-nucleon scattering at low energy, phase shift and scattering length, effective range theory, experimental determination of low energy parameters. c. Nature of nuclear forces and Meson theory of nuclear force.	**12**	CO2	K2
Module 3:	**Nuclear Models:** a. Liquid drop model, Weizsacker's mass formula, stable and unstable nuclei, mass parabolas. b. Nuclear shell model, energy levels in a three-dimensional harmonic oscillator well potential, spin orbit interaction, prediction of magic numbers, ground state spins and parities. c. Magnetic moments, Schmidt lines, nuclear quadrupole moments, and collective model.	**10**	CO1	K2, K3
Module 4:	**Nuclear Transformations:** a. Alpha decay, barrier penetration problem, Gamow's theory of alpha decay, Geiger-Nuttal law, alpha spectra and nuclear energy levels. b. Beta decay, experiments in beta spectra, neutrino hypothesis, Fermi's theory of beta decay, Kurie plots, ft values, allowed and forbidden transitions, selection rules, electron capture, parity violation in beta decay, experimental verification, measurement of neutrino helicity.	**10**	CO3	K3

	c. Gamma transitions, multipole radiations, quantum theory of the transition probability, selection rules, angular correlation, calculations of transition rates and comparison with experiments, internal conversion.			
Module 5:	**Nuclear Reactions:** a. Rutherford scattering, cross-sections, decay rates, resonances, Breit-Wigner formula, nuclear fission and fusion processes.	**4**	CO3	K3
Module 6:	**Elementary Particles:** a. Classification of elementary particles; properties of quarks and leptons, properties of mesons and baryons. Classification of fundamental forces; Strong, Weak and Electromagnetic interactions. b. Introduction to Feynman diagrams, relativistic kinematics, quark model and eightfold way. c. Particle quantum numbers; charge, isospin, strangeness and parity, Gell-Mann Nishijima formula, conservation laws and symmetries	**10**	CO4	K4
Module 7:	**Particle accelerators and detectors:** a. Introduction to modern accelerators, event rates and luminosity. Large detector systems at electron-positron, electron-proton and hadron colliders. b. Interaction of particles with matter, principle of gas chambers, silicon detectors, scintillators, time-of-flight detectors, and calorimetry.	**6**	CO5	K2
Pedagogy:	Lectures / tutorials/assignments. Sessions shall be interactive in nature to enable peer group learning.			
Texts:	1. H. Enge, Introduction to Nuclear Physics, Addison- Wesley (1974). 2. E. Segre, Experimental Nuclear Physics, John Wiley (1960). 3. V. Devanathan, Nuclear Physics, Alpha Science International Ltd, (2011). 4. S. N. Ghoshal, Nuclear Physics, S. Chand and Co. (2019).			
Web Resources:	https://nptel.ac.in/courses/115104043			

Title of the Course	Atomic Physics
Course Code	PHY-5007
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course is aimed at understanding the atomic structure and analyzing atomic spectra.	
Course Outcomes:	Students will be able to	**Mapped to PSO**
	CO 1. Understand atomic structure	PSO1
	CO 2. Analyze optical and X-ray spectra of atoms	PSO1
	CO 3. Apply the knowledge of atomic structure to understand the effect of the interaction of atoms with electric and magnetic fields.	PSO1
	CO 4. Evaluate the spin-orbit interaction, exchange interaction, and electron-electron	PSO1

	interaction in atoms with different atomic numbers.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Early Atomic Physics** Atomic spectra of hydrogen, The Bohr's theory, Relativistic effects, Moseley and atomic number, Radiative decay, Einstein A and B coefficients, The Zeeman effect.	**6**	CO1, CO2	K2, K4
Module 2:	**One-electron atoms**: The Schrödinger equation for one-electron atoms, energy levels, the eigenfunctions of the bound states, expectation values. Transitions, selection rules, parity, spin of the electron, the spin-orbit interaction, Fine structure of hydrogenic atoms, The Lamb shift, transitions between fine-structure levels.	**12**	CO1, CO2	K2, K4
Module 3:	**Two-electron atoms:** The Schrödinger equation for two-electron atoms, The ground state of two-electron atoms, Excited states of two-electron atoms. Doubly excited states of two electron atoms.	**12**	CO1, CO2	K2, K4
Module 4:	**Many-electron atoms**: Shell structure and the periodic table, The central field approximation, The Hartree-Fock method and the self-consistent field, Corrections to the central field approximation. Correction effects, *L-S* coupling and *j-j* coupling. Fine structure in the alkalis.	**15**	CO1, CO2	K2, K4
Module 5:	**Interaction of atoms with electromagnetic radiation and with static and magnetic field:** Many electron atoms in an electromagnetic field, selection rules for electric dipole transitions, Oscillator and line strengths, Retardation effects, Magnetic dipole and electric quadrupole transitions, The spectra of the alkalis, Helium and the alkaline earths, Atoms with several optically active electrons, Multiplet structure, X-ray spectra, The stark effect, The Zeeman effect.	**15**	CO3, CO4	K3, K5

Pedagogy:	Lectures/tutorials/assignments. Sessions shall be interactive in nature to enable peer group learning
Texts:	Physics of Atoms and Molecules, B. H. Bransden, C. J. Joachain, Pearson (2004), Second Edition
References/ Readings:	1. Atomic Physics, C. J. Foot, Oxford Master Series in Physics (2005) 2. Atomic Physics, D. C. Jones, CRC Press/Sarat Book House. (2018) 3. Atomic Physics, S. N. Ghoshal, S. Chand Publishing (2007)

Discipline Specific Elective Courses

Title of the Course	General Physics Practical
Course Code	PHY-5206
Number of Credits	4
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course provides laboratory training in performing experiments that verify important physical laws and using modern and novel techniques of measurements.	
Course Outcomes:	Student will be able to	**Mapped to PSO**
	CO 1. Estimate and translate errors and report quantities up to last significant digit.	PSO4
	CO 2. Demonstrate the ability to use selected pieces of measuring devices including the multimeter, oscilloscope, and AC and DC power supplies, Lock-in Amplifier.	PSO4
	CO 3. Apply the appropriate physics to the physical situation presented.	PSO4
	CO 4. Employ proper techniques when making scientific measurements.	PSO4

	CO 5. Formulate and report scientific conclusions based on data analysis.		PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Short Lecture Course on – Theory of errors, Treatment of Errors of observation, linear least squares fitting and Data analysis. The experiments on the following topics (any 12) are to be performed with emphasis on the estimation and calculation of errors. 1. Types of Statistical Distributions 2. Analysis of Sodium Spectrum – Quantum defect and Effective quantum number 3. Michelson Interferometer/Fabry-Perot Interferometer 4. Diffraction experiments using laser– single slit, double slit, grating 5. Polarization experiments using laser–linearly and elliptically polarized light 6. Statistical Distribution of radioactive decay 7. Verification of Inverse Square Law using GM counter 8. Linear Absorption Coefficient of Aluminum using GM counter 9. Verification of Debye Relaxation Law and measurement of thermal relaxation of serial light bulb 10. Thermal diffusivity of Brass 11. Thermometry – measurement of thermoemf of Iron- Copper (Fe-Cu) thermocouple as a function of temperature and verification of law of intermediate metals 12. Calibration of Lock-in Amplifier 13. Measurement of mutual inductance of a coil using lock-in amplifier 14. Measurement of low resistance using lock-in amplifier 15. X-ray Emission – characteristics lines of a W target 16. Experiments using Strain Gauge 17. Ultrasonic Interferometer	120	CO1, CO2, CO3, CO4, CO5	K2, K3, K5

	18. Nonlinear dynamics – Feigenbaum circuit 19. Nonlinear dynamics – Chua's circuit 20. Verification of Percolation phenomena 21. Measurement of electrical resistance of Ni wire to verify para to ferromagnetic phase transition 22. Measurement of electrical resistance of NiTi based shape memory alloy 23. Measurement of Young's modulus of Brass by Flexural vibrations 24. Measurement of Rigidity modulus of Brass			
Pedagogy:	Lectures and Laboratory Experiments.			
References/ Readings:	1. P. R. Bevington and D. K. Robinson, Data Reduction and Error Analysis for the Physical Sciences. McGraw Hill (Indian Edition), 2015. 2. R. Srinivasan, K. R. Priolkar, and T. G. Ramesh, A Manual on Experiments in Physics. Indian Academy of Sciences, 2018.			

Title of the Course	Design and Fabrication Practical – II
Course Code	PHY-5207
Number of Credits	4
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	PHY-5202			
Course Objectives:	To develop interest and skill for designing and building Physics experiments and experimental setups			
Course Outcomes:	Student will be able to		**Mapped to PSO**	
	CO 1. Understand the principle of working of experiments.		PSO4	
	CO 2. Design Physics experiments and experimental setups.		PSO4	
	CO 3. Construct Physics experiments and test them.		PSO4	
	CO 4. Evaluate the performance and systematic errors in their setups.		PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**

Module 1:	Design and construct a Stephan's Constant setup, evaluate its performance and test it for measuring Stephan's Constant.	**30**	CO1, CO2, CO3, CO4	K2, K4, K5, K6
Module 2:	Design and construct a thermal and electrical conductivity setup for measuring thermal and electrical conductivity of a metal and measure thermal and electrical conductivity of copper.	**30**	CO1, CO2, CO3, CO4	K2, K4, K5, K6
Module 3:	Design and construct a thermal diffusivity setup and use it to measure thermal diffusivity of brass.	**30**	CO1, CO2, CO3, CO4	K2, K4, K5, K6
Module 4:	Design and construct setup for measuring dielectric constant of a liquid and use it to measure dielectric constants of polar and non-polar liquids.	**30**	CO1, CO2, CO3, CO4	K2, K4, K5, K6
Pedagogy:	Laboratory work and Self Study			
Texts:	R. Srinivasan, K. R. Priolkar and T. G. Ramesh Experiments in Physics - Laboratory Manual, Indian Academy of Sciences 2017.			