Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	B010701T/PY413	**Title of the Course**	Advanced Mathematical Physics	**L**	**T**	**P**	**C**
Year	1st	**Semester**	1st	**5**	**1**	**0**	**4**
Pre-Requisite	B.Sc. with Physics	**Co-requisite**					
Course Objectives	This Course offers an introduction to mathematical techniques required for physics. After successful completion of the course the students will learn the complex analysis in detail. They will also learn the special functions and their applications. This course also provide an introduction to Green's functions, tensor analysis and group theory which are basics tools for many areas of theoretical physics.						

Course Outcomes	
CO1	Explain the algebra and application of complex functions.
CO2	Analyze the Bessel, Gamma and Beta functions and the partial differential equations.
CO3	Evaluate the Green's function of simple operators. Learn the algebra and calculus of tensors.
CO4	Analyze the algebra of finite and continuous groups.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Complex analysis	Complex variables and applications: analytic functions, contour integration, residue calculus: Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem, Application in solving Definite Integrals.	8	1
2	Special functions-I	Properties of Legendre Polynomials of First Kind, Rodrigues Formula, Generating Function, Orthogonality and recurrence relations. Expansion of function in a series of Legendre Polynomials. Hermite and Laguerre Special Functions.	7	1
3	Special functions-II	Bessel Functions of the First Kind, Generating Function, simple recurrence relations, Zeros of Bessel Functions and Orthogonality. Beta and gamma functions and their applications.	7	2
4	Partial differential equations	Introduction to partial differential equations, Laplace, wave and heat equations in two and three dimensions.	7	2
5	Green's function	Introduction to Green's functions method, Green's function as a solution to Poisson's equation with a point source, symmetry of Green' s functions, application in quantum mechanical scattering theory	7	3
6	Tensors	Covariant and Contravariant tensors, Tensor algebra, linear combinations, direct product, contraction, Affine connections, Christoffel symbols, Curvature tensor, covariant differentiation, gradient, curl and divergence	8	3
7	Group Theory-I	Classification and examples of (finite) groups, homomorphisms, isomorphisms, representation theory for finite groups, reducible and irreducible representations, Schur's Lemma and orthogonality theorem.	8	4
8	Group Theory-II	Introduction to continues groups: Lie Groups and Lie algebra, Rotation groups O(N), SO(2), SO(3) and their irreducible representations, U(N), SU(2) and SU(3) groups.	8	4

Reference Books:

1. G.B. Arfken, *Mathematical Methods for Physicists*
2. P. Dennery and A. Krzywicki, *Mathematics for Physicists*
3. P.K. Chattopadhyay, *Matrices and Tensors in Physics*
4. A.W. Joshi, *Complex Variables and Applications*
5. R.V. Churchill and J.W. Brown, *Complex Variables and Applications*
6. P.M. Morse and H. Feshbach, *Methods of Theoretical Physics (Volume I and II)*

e-Learning Source:

1. https://www.freebookcentre.net/Physics/Mathematical-Physics-Books.html
2. https://nptel.ac.in/courses/115106086/
3. www.youtube.com

Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	3					1	3	3		2	3	2	2
CO2	3					1	3	3		2	3	2	2
CO3	3					1	3	3		3	3	3	2
CO4	3					1	3	3		3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	B010702T/PY414	**Title of the Course**	**Quantum Mechanics-I**	**L**	**T**	**P**	**C**
Year	1st	**Semester**	1st	**5**	**1**	**0**	**4**
Pre-Requisite	B.Sc. with Physics	**Co-requisite**					
Course Objectives	This Course offers a systematic introduction to quantum mechanics. After successful completion of the course, students will be able to apply the quantum mechanics to one and three dimensional problems. They will also get a understanding of symmetries in nature and identical particles.						

Course Outcomes	
CO1	Explain the origin of quantum mechanics and learn the mathematics needed to formulate quantum mechanics.
CO2	Analyze the postulates of quantum mechanics and apply them in one dimensional problems.
CO3	Analyze three dimensional problems in quantum mechanics. Understand the physics behind orbital and spin angular momentum.
CO4	Differentiate the symmetries in quantum mechanics. Understand the physics of the identical particles.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Introduction to Quantum Mechanics	Brief introduction to origin of quantum Physics: ultraviolet catastrophe, photoelectric effect, Bohr's atomic model, Compton effect, Wilson -Sommerfeld quantization rule, Wave packets, group and phase velocities.	7	1
2	Mathematical Preliminaries	Operators: their eigenvalues and eigen functions, orthonormality, completeness and closure. Generalized uncertainty principle. Unitary transformations, change of basis. Matrix representation of operators. Continuous basis, position and momentum representation and their connection, Dirac notation.	7	1
3	Postulates of Quantum Mechanics	Basic postulates of quantum mechanics: state of a system, The Superposition Principle, Measurement of physical observables. Time evolution of system's state: Schrodinger, Heisenberg and interaction pictures, Density operator, Pure state and mixed state density operators. Discrete and continuous spectra	8	2
4	Quantum Mechanics in one dimension	Energy eigen values and eigen functions for simple one dimensional problems: The Free Particle, The Potential step, Tunneling through potential barrier, The infinte potential well and one dimensional harmonic oscillator (algebraic method). (problems based on these topics)	8	2
5	Quantum Mechanics in a central potential	Angular momentum operator, expressions of L^2 and L_z, eigen values and eigen functions of L^2 and L_Z, hydrogen atom, solution of radial equation, energy eigen values, eigen functions of H atom, orthogonality of eigen functions, rigid rotator, matrix representation of $L^{2,}$ L_x, L_y, L_z	8	3
6	Spin Angular Momentum	Spin angular momentum operator and their algebra, generalized angular momentum, generator of rotation and their commutation relations, spin-1/2 matrices, coupling of angular momenta, Clebsch-Gordon Coefficients.	7	3
7	Symmetries in quantum mechanics	Conservation laws and degeneracy associated with symmetries, Discrete symmetries: CPT symmetry, Continuous symmetries: space and time translations, rotations.	7	4
8	Identical Particles	Systems of identical particles: exchange degeneracy, symmetrization postulate, construction of symmetric and anti-symmetric wave functions from unsymmetrized functions. The Pauli exclusion principle. Introduction to second quantization. Creation and annihilation operators for Fermions and Bosons. Fock states.	8	4

Reference Books:

1. C. Cohen-Tannoudji, B. Diu and F. Laloe, *Quantum Mechanics (Volume I).*
2. L.I. Schiff, *Quantum Mechanics.*
3. E. Merzbacher, *Quantum Mechanics*
4. R.P. Feynman, *Feynman Lectures on Physics (Volume3)*
5. A. Messiah, *Quantum Mechanics (Volume I)*
6. R. Shankar, *Principles of Quantum Mechanics*

e-Learning Source:

1. https://nptel.ac.in/courses/115/102/115102023/
2. https://nptel.ac.in/courses/115/104/115104096/
3. https://nptel.ac.in/courses/115/103/115103104/
4. https://nptel.ac.in/courses/115/101/115101107/

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3					1	3	3		2	3	2	
CO2	3					1	3	3		2	3	2	
CO3	3					1	3	3		3	2	3	
CO4	3					1	3	3		3	3	3	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	B010703T/PY415	**Title of the Course**	**Classical Mechanics**	**L**	**T**	**P**	**C**
Year	1st	**Semester**	1st	**5**	**1**	**0**	**4**
Pre-Requisite	B.Sc. with Physics	**Co-requisite**					
Course Objectives	The purpose of this course is to introduce the Lagrangian and Hamiltonian formulation of classical mechanics. After successful completion of the course, students will get a good understanding of canonical transformations and Hamilton-Jacobi equation. This course also includes an introduction to advanced topic like perturbation theory in classical mechanics and dynamics of non-linear systems.						

Course Outcomes	
CO1	Evaluate the equation of motion using the lagrangian and hamiltonian formulation of classical mechanics.
CO2	Analyze the canonical tranformation of dynamical variables and to understand the Hamilton-Jacoby equation.
CO3	Analyze the dynamics of rigid bodies and the theory of small oscillations.
CO4	Explain the classical perturbation theory and the dynamics of non-linear systems.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Lagrangian dynamics	Newtonian mechanics and its limitations. Constraints and their classification. Principle of virtual work. D' Alembert's principle. Generalised coordinates. Deduction of Lagrange's equations from D'Alembert's Principle. Generalised momenta and energy. Cyclic coordinates. conservation laws and symmetry. (Problems based on these topics)	8	1
2	Hamiltonian dynamics	Principle of least action. Hamilton's principle. The calculus of variations. Hamilton's principle and characteristic functions, Derivation of Hamilton's equations of motion for holonomic systems from Hamilton's principle.	8	1
3	Canonical Transformation	Canonical Transformations and their Generating functions. Poisson bracket. Poisson's Theorem. Poisson brackets and equation of motion, conservation laws, angular momentum.	7	2
4	Hamilton Jacobi Theory	Hamilton-Jacobi equation and its connection with canonical transformation, harmonic oscillations, separation of variables, action-angle variables and Kepler problem	7	2
5	Rigid Body Dynamics	Degrees of freedom, orthogonal transformations, infinitesimal rotations, rotating coordinate systems, centrifugal and Coriolis force. Angular momentum and kinetic energy of a rigid body, Inertia tensor, principal axes transformation Euler's equation of motion for a rigid body, Applications: torque free motion of symmetric top, precession of Earth's axis of rotation	8	3
6	Small Oscillations	Idea of small oscillations, eigenvalue equation, normal coordinates and normal modes (problems based on these topics).	7	3
7	Continuous Media and classical perturbation theory	Continuous Media: Coupled pendula, triatomic molecule, Linear chain of interacting particles, elastic rod problem, Lagrangian formalism, stress energy tensor. Classical Perturbation Theory: Time dependent perturbation theory, harmonic oscillator.	8	4
8	Nonlinear Dynamics	Nonlinear dynamics: Qualitative discussion of Classical Choas, Phase space dynamics and stability analysis, Chaotic trajectories and Liapunov exponents	7	4

Reference Books:

1. H. Goldstein, *Classical Mechanics.*
2. L.D. Landau and E.M. Lifshitz, *Mechanics*
3. I.C. Percival and D. Richards, *Introduction to Dynamics*
4. J.V. Jose and E.J. Saletan, *Classical Dynamics: A Contemporary Approach*
5. E.T. Whittaker, *A Treatise on the Analytical Dynamics of Particles and Rigid Bodies*
6. N.C. Rana and P.S. Joag, *Classical Mechanics*

e-Learning Source:

1. https://nptel.ac.in/courses/115/105/115105098/
2. https://nptel.ac.in/courses/115/106/115106068/
3. https://nptel.ac.in/courses/122/106/122106027/

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3					1	3	3		3	3	2	2
CO2	3					1	3	3		3	3	3	2
CO3	3					1	3	3		3	3	3	2
CO4	3					1	3	3		3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	B010704T/PY416	**Title of the Course**	**Statistical Mechanics**	**L**	**T**	**P**	**C**
Year	1st	**Semester**	1st	**5**	**1**	**0**	**4**
Pre-Requisite	B.Sc. with Physics	**Co-requisite**					
Course Objectives	This Course offers a systematic introduction to statistical mechanics. After successful completion of course, the students will get a basic understanding of the statistical description of Bose-Einstein and Fermi Dirac systems. They will also understand the physics of the phase transitions and non-equilibrium phenomena.						

Course Outcomes	
CO1	Explain the basic concepts, terminology and need of statistical mechanics.
CO2	Analyze the statistical mechanics of classical and quantum systems.
CO3	Differentiate the Bose-Einstein and Fermi-Dirac statistics to understand the properties of many real life systems.
CO4	Analyze the physics of phase transition and learn the non-equilibrium processes in nature.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Statistical basis of thermodynamics	Introduction to statistical physics, The macroscopic and the microscopic states, phase space and phase space trajectory, concept of statistical ensembles, distribution function, mean value of a physical quantity, statistical equilibrium, Connection between statistical mechanics and thermodynamics, Law of increase of entropy.	8	1
2	Classical statistical mechanics	Liouville's Theorem and its significance, Micro-canonical, canonical and grand canonical ensembles; Energy and Density fluctuations; Equi-partition and virial theorem, partition function, The Boltzmann distribution, Derivation of thermodynamic properties for simple systems: (1) classical ideal gas, (2) system of classical harmonic oscillators, (3) system of magnetic dipoles in magnetic field	8	1
3	Quantum Statistical mechanics	Quantum mechanical ensembles theory, calculation of density matrix and partition function for symple systems: (1) free particle in a box, (2) a linear harmonic oscillator, (3) electron in a magnetic field.	8	2
4	Bose-Einstein and Fermi-Dirac statistics	Symmetric and Antisymmetric Wave functions. Micro-canonical ensemble of ideal Bose, Fermi and Boltzmann gases, derivation of Bose, Fermi and Boltzmann statistics, Grand Partition function of ideal Bose and Fermi gases	7	2
5	Applications of B-E statistics	Thermodynamics of ideal Bose gas, Bose-Einstein condensation: condensation temperature, specific heat, entropy and pressure, Blackbody radiation and Planck's law of radiation.	7	3
6	Applications of F-D statistics	Thermodynamics of ideal Fermi gas, Electrons in metals, Richardson effect, Magnetism of an electron gas Pauli paramagnetism, Landau diamagnetism, De-Hass Van Alphen effect.	7	3
7	Phase transition and Critical Phenomenon	Type of phase transitions, first and second order phase transitions. Ising model: mean-field theories of the Ising model in two and three dimensions. Landau theory of phase transition, critical exponents and universality classes.	8	4
8	Diffusion and non-equilibrium phenomena	Diffusion equation. Random walk and Brownian motion. Introduction to non-equilibrium processes. Onsager reciprocal relations. Boltzmann transport equation and transport phenomena	7	4

Reference Books:

1. K. Huang, *Statistical Mechanics*, John Wiley and Sons, 2nd Edition, 1987.
2. R.K. Pathria, *Statistical Mechanics*, Academic Press, 3rd Edition, 2011.
3. E.M. Lifshitz and L.P. Pitaevskii, *Physical Kinetics*, Pergamon Press, 2012.
4. D.A. McQuarrie, *Statistical Mechanics*, Harper and Row Publication, 2000.
5. L.P. Kadanoff, *Statistical Physics: Statistics, Dynamics and Renormalization*, World Scientific Press, 2000.

e-Learning Source:

1. https://nptel.ac.in/courses/115/103/115103113/
2. https://nptel.ac.in/courses/115/106/115106111/
3. https://youtu.be/D1RzvXDXyqA

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3					1	3	3		3	3	2	2
CO2	3					1	3	3		3	3	3	2
CO3	3					1	3	3		3	3	3	2
CO4	3					1	3	3		3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	B010805P/PY417	**Title of the Course**	Advanced Physics Lab I	**L**	**T**	**P**	**C**
Year	1st	**Semester**	1st	**0**	**0**	**4**	**2**
Pre-Requisite	B.Sc. with Physics	**Co-requisite**					
Course Objectives	The objective of this course is to develop students' ability to analyze and interpret experimental data by performing optics experiments such as diffraction, interference, polarization, and laser studies, alongside electronics experiments involving FET, MOSFET, UJT, SCR characteristics and ultrasonic measurements, to enhance their understanding of fundamental principles, device behaviour, and practical applications in physics and electronics.						

Course Outcomes	
CO1	Develop the ability to determine wavelengths using reflection grating, analyze laser beam characteristics, study polarization using Babinet's compensator, measure fringe parameters with Etalon, and verify Fresnel's formula to understand fundamental optical phenomena and measurement techniques.
CO2	Analyze the operational characteristics and parameters of various electronic and ultrasonic devices such as FET, MOSFET, UJT, SCR, and ultrasonic interferometer to evaluate their applications in electronic circuits and material characterization.

Experiment No.	Title of the Experiment	Aim of the Experiment (*Offline)	Contact Hrs.	Mapped CO
1	Reflection Grating	To determine the wavelength of prominent lines of mercury with the help of reflection grating.	6	CO1
2	Laser	(a) To plot the power distribution of a laser beam. (b) To determine the divergence of a given laser source.	6	CO1
3	Babinet Compensator	The study of elliptically and circularly polarized light with help of Babinet's compensator.	6	CO1
4	Etalon	To determine the thickness of air film between glass plates, the integral part of the order of fringes at the center and the fractional part, if any, in an Etalon.	6	CO1
5	Fresnel's Formula	To verify Fresnel's formula of reflection for plane polarized light and to determine Brewster's angle for glass.	6	CO1
6	Ultrasonic Interferometer	To determine the velocity of ultrasonic waves in a liquid medium and calculate its compressibility	6	CO2
7	Field Effect Transistor (FET)	To study the static characteristics of a Field Effect Transistor (FET) in both common-source and drain characteristics configurations, and to determine important device parameters such as drain resistance, transconductance, and amplification factor.	6	CO2
8	Metal Oxide Field Effect Transistor (MOSFET)	To study and plot the transfer characteristics and output characteristics of an n-channel enhancement-mode MOSFET.	6	CO2
9	Uni-Junction Transistor (UJT)	To investigate the static characteristics of a Uni-Junction Transistor (UJT), and determine its intrinsic stand-off ratio and peak point voltage.	6	CO2
10	Silicon Controlled Rectifier (SCR)	To study the V-I characteristics of a Silicon Controlled Rectifier (SCR).	6	CO2

Reference Books:

1. **B.L. Worsnop, H.T. Flint**, *Advanced Practical Physics for Students*, Methuen & Co., Ltd., London, 1962, 9e.
2. **Indu Prakash, Ramakrishna**, *A Textbook of Practical Physics*, Kitab Mahal, Allahabad, 2020, 11e.
3. **G. L. Squires**, *Practical Physics*, Cambridge University Press, 2001, 4e.
4. **C.L. Arora**, *B.Sc. Practical Physics*, S. Chand Publishing, New Delhi, 2022, 20e.
5. **M. P. Srivastava**, *Advanced Practical Physics*, New Age International Publishers, 2001, 2e.
6. **D. Chattopadhyay, P.C. Rakshit**, *An Advanced Course in Practical Physics*, New Central Book Agency, Kolkata, 2022, Revised Edition.
7. **S. Panigrahi, B. Mallick**, *Engineering Practical Physics*, Cengage Learning India, 2015, 1e.
8. **K. G. Mazumdar, B. Ghosh**, *Exploratory Experiments in Physics*, University Press, 1999, 1e.
9. **K.K. Sharma**, *Instrumentation and Experimental Techniques in Physics*, PHI Learning Pvt. Ltd., New Delhi, 2005, 1e.
10. **S. Rajasekar, R. Chandrasekar**, *Quantum Mechanics and Modern Physics Experiments*, Pearson Education, 2011, 1e.

e-Learning Source:

1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74
2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities.

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2		2			2	3	2	3			
CO2	3	2					2	3	3			2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	B010801T/PY418	**Title of the Course**	**Condensed Matter Physics**	**L**	**T**	**P**	**C**
Year	1st	**Semester**	2nd	**5**	**1**	**0**	**4**
Pre-Requisite	B.Sc. with Physics	**Co-requisite**					
Course Objectives	To develop an in-depth understanding of the quantum behavior of electrons in solids, band theory, electronic transport, magnetic properties, and superconductivity. The course aims to equip students with the theoretical and conceptual tools needed to analyze condensed matter systems using advanced models.						

Course Outcomes	
CO1	Analyze the behavior of free and nearly-free electrons in solids using quantum statistical methods and interpret their physical significance through models like Kronig–Penney and Bloch's theorem.
CO2	Evaluate the formation of energy bands in solids and deduce electronic properties of metals, semiconductors, and insulators based on band structure and density of states.
CO3	Interpret optical and dielectric properties of materials concerning band structure and electronic transitions, and explain phenomena such as photoluminescence, plasmons, and excitons.
CO4	Formulate advanced models of magnetism and superconductivity, including BCS theory, Hubbard model, and quantum Hall effects, to predict the physical behavior of complex condensed matter systems.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Free Electron Theory in Solids**	Free electrons in solids, Fermi-Dirac statistics and Fermi gas at T=0 K, Density of states, Fermi energy, Fermi surface, Electronic specific heat capacity in metals, Thermionic emission from metals, Limitations of free electron theory.	7	CO1
2	**Electrons in Periodic Potentials**	Electrons in periodic potentials, Bloch's theorem and its implications, Kronig–Penney model, nearly free electron model, Tight-binding approximation and LCAO, Wannier functions.	8	CO1
3	**Electronic Band Structure and Density of States**	Formation of energy bands, Band structure in metals, semiconductors, and insulators, Density of states in bands, Examples of real band structures, Fermi surfaces in metals and semiconductors.	8	CO2
4	**Charge Transport in Solids**	Motion of electrons and holes in bands, Effective mass, Electron scattering and relaxation time, Boltzmann transport equation, Electrical conductivity in metals, Thermoelectric effects, Wiedemann–Franz Law.	7	CO2
5	**Interacting Electron Systems**	Review of approximations: free electron, nearly free, tight-binding, Hartree-Fock approximation, Electron-electron interactions in solids, Dielectric constant of metals and insulators, Screening and polarization.	7	CO3
6	**Optical Properties of Solids**	Interband and intraband electronic transitions, Relation between optical properties and band structure, Reflectivity, absorption, and dispersion, Kramers–Kronig relations, Optical constants (n, k), Photoluminescence and electroluminescence, Plasmons, excitons, and polarons.	7	CO3
7	**Magnetism in Solids**	Diamagnetism (including Landau diamagnetism), Paramagnetism (Langevin, van Vleck), Exchange interactions and origin of magnetism, Band theory of ferromagnetism, Superexchange and double exchange, Hubbard model, Antiferromagnetism, Neel temperature, Spin waves and magnons.	8	CO4
8	**Superconductivity and Superfluidity**	Superconductivity: Meissner effect, London equations, Type I and II superconductors, Ginzburg–Landau theory, Cooper pairs and BCS theory, Josephson effect, SQUIDs, Weakly interacting Bose gas, Superfluidity, 2D electron gas in magnetic field, Landau levels and degeneracy, Integer and fractional Quantum Hall effects.	8	CO4

Reference Books:

1. **Hook, J. R. and Hall, H. E.** *Solid State Physics*, 2nd Edition, Wiley, 2010. ISBN: 9780471928053
2. **Kittel, C.** *Introduction to Solid State Physics*, 8th Edition, Wiley, 2004. ISBN: 9780471415263
3. **Ibach, H. and Lüth, H.** *Solid-State Physics: An Introduction to Principles of Materials Science*, 4th Edition, Springer, 2009. ISBN: 9783540938043
4. **Rosenberg, H. M.** *The Solid State: An Introduction to the Physics of Crystals for Students of Physics, Materials Science, and Engineering*, 3rd Edition, Oxford University Press, 1988. ISBN: 9780198518703
5. **Blakemore, J. S.** *Solid State Physics*, 2nd Edition, Cambridge University Press, 1985. ISBN: 9780521313919
6. **Ashcroft, N. W. and Mermin, N. D.** *Solid State Physics*, Brooks/Cole (Cengage Learning), 1976. ISBN: 9780030839931
7. **Madelung, O.** *Introduction to Solid-State Theory*, Springer, 1978. ISBN: 9783540080513
8. **Kittel, C.** *Quantum Theory of Solids*, Wiley, 1987. ISBN: 9780471624122
9. **Mahan, G. D.** *Many-Particle Physics (Physics of Solids and Liquids)*, 3rd Edition, Springer, 2000. ISBN: 9780306463389

e-Learning Source:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/
3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx
4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)												
PO-PSO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	3	2	–	–	–	–	3	3	–	1	3	–	–
CO2	3	2	–	–	–	–	3	3	3	-	3	2	-
CO3	3	2	–	–	–	2	3	3	3	2	3	1	-
CO4	3	2	–	–	–	2	3	3	3	3	3	3	-

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name and Sign of Program Coordinator	**Sign and Seal of HoD**

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	B010802T/PY419	**Title of the Course**	**Electrodynamics**	**L**	**T**	**P**	**C**
Year	1st	**Semester**	2nd	**5**	**1**	**0**	**4**
Pre-Requisite	B.Sc. with Physics	**Co-requisite**					
Course Objectives	This Course offers a systematic introduction to classical electrodynamics. After successful completion of the course the students will be able to learn the electromagnetic waves in nonconducting as well as conducting mediums. This course also offers a proper understanding of radiation produced due to accelerated charges and its scattering. A covariant formulation of electrodynamics has been also discussed.						

Course Outcomes	
CO1	Evaluate the field and potentials in electrostatics and magnetostatics and solve the Poisson and Laplace equations.
CO2	Analyze the Maxwell's equation in vacuum as well as in matter. Understand the physics of electromagnetic waves in conducting medium and non-conducting medium.
CO3	Calculate the reflection and refraction coefficients of EM waves. Analyze the propagation of EM waves between two perfectly conducting planes and in hollow conductors. Calculate the radiation from the accelerated charges.
CO4	Analyze the scattering of radiation and learn the covariant formulation of classical electrodynamics.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Review of electromagnetic theory	Gauss law in electrostatics, dielectrics and polarization, Gauss law in magnetism, Ampere's law in magneto-statics, Faraday's law of electromagnetic induction (Problems based on these topics)	8	1
2	Boundry value problems	Poisson and Laplace equations and their solutions in cartesian co-ordinates, solutions of Laplace equation in cylindrical and spherical coordinates by orthogonal functions,	8	1
3	Maxwell's equations	Idea of displacement current, Maxwell's equations in vacuum, Maxwell's equations in matter. Scalar and vector potentials. Gauge transformations. Coulomb and Lorentz Gauge, Conservation of energy and momentum, Poynting's theorem, Maxwell's Stress tensor.	7	2
4	Electromagnetic waves-I	Propagation of EM waves in non-conducting medium. Propagation of EM waves in a conducting medium. Skin depth. Linear, circular and elliptical polarization. Oblique incidence – The Fresnel Equations, Total internal reflection, Brewster's angle.	7	2
5	Electromagnetic waves-II	Reflection and refraction from a metallic surface. Propagation of waves between perfectly conducting planes. Waves in hollow conductors. T. E. and T. M. modes. Rectangular wave guides (TE and TM cases). Resonant cavities.	8	3
6	Radiation from accelerated charges	Lienard Weichert potentials. Fields produced by charged particles in motion. Radiation from accelerated charged particles, Larmor's formula and its relativistic generalization.	7	3
7	Scattering of radiation	Scattering of electromagnetic radiation by free charges. Thomson scattering. Scattering by a system of charges, dipole radiation. Dispersion relations in plasma.	7	4
8	Relativistic Electrodynamics	Covariant formulation of electrodynamics, Electromagnetic field tensor, Transformation of electromagnetic fields, Field due to a point charge in uniform motion, Energy-momentum tensor and the conservation laws for the electromagnetic field; the equation of motion of a charged particle in an electromagnetic field	8	4

Reference Books:

1. K. Huang, *Statistical Mechanics*, John Wiley and Sons, 2nd Edition, 1987.
2. R.K. Pathria, *Statistical Mechanics*, Academic Press, 3rd Edition, 2011.
3. E.M. Lifshitz and L.P. Pitaevskii, *Physical Kinetics*, Pergamon Press, 2012.
4. D.A. McQuarrie, *Statistical Mechanics*, Harper and Row Publication, 2000.
5. L.P. Kadanoff, *Statistical Physics: Statistics, Dynamics and Renormalization*, World Scientific Press, 2000.

e-Learning Source:

1. https://nptel.ac.in/courses/115/103/115103113/
2. https://nptel.ac.in/courses/115/106/115106111/
3. https://youtu.be/D1RzvXDXyqA

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3					1	3	3		3	3	2	1
CO2	3					1	3	3		3	3	3	1
CO3	3					2	3	3		3	3	3	1
CO4	3					2	3	3		3	3	3	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Effective from Session: 2025-26							
Course Code	**B010803T/PY420**	**Title of the Course**	**Nuclear & Particle Physics**	**L**	**T**	**P**	**C**
Year	**1st**	**Semester**	**2nd**	**5**	**1**	**0**	**4**
Pre-Requisite	**B.Sc. with Physics**	**Co-requisite**	**None**				
Course Objectives	This course offers a systematic introduction to elementary nuclear and particle physics. After successful completion of the course the students will be able to learn the basic properties of a nucleus and various models. This course also offers introduction to nuclear decay, nuclear reactions, accelerators and various types of detectors. Fundamental particles, various symmetries and some contemporary ideas in standard model of particle physics have been also discussed.						

Course Outcomes

CO1	Explain the basic Nuclear properties and models governing them.
CO2	Analyze the kinematics of nuclear decay and nuclear reactions.
CO3	Analyze the theory and working of accelerators and detectors. Understand the physics of elementary particles.
CO4	Explain the symmetries in particle physics. Overview of some current trends in standard model of particle physics.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**General Properties of Nucleus & Nuclear Forces**	Mass, binding energy, radii, density, angular momentum, Parity and symmetry, magnetic dipole moment and electric quadrupole moment. Characteristics of nuclear forces-Range and strength, Simple theory of two nucleon system deuterons, Spin states of two nucleon system, Effect of Pauli's exclusion principle, Magnetic dipole moment and electric quadrupole moment of deuteron -The tensor forces.	8	CO1
2	**Nuclear Models**	Liquid drop model: Weizsacker's Semi-Empirical Mass formula and binding energy, achievements and limitations of liquid drop model, Nuclear shell model (with the harmonic oscillator potential): spin-orbit coupling and magic numbers, achievements and limitations of the Shell Model	7	CO1
3	**Nuclear Decay**	Alpha decay; energetics of alpha decay, Geiger-Nuttal law, Gamow theory of alpha decay. Beta decay: Neutrino hypothesis, energetics of beta decay, Fermi theory of beta decay, Fermi-Curie plot, comparative half life. Selection rules: allowed and forbidden transitions, Idea of electron capture, Gamma decay: energetic of Gamma decay, Multipole radiations, Selection rules, Idea of Internal Conversion of Gamma rays and Coulomb excitation.	8	CO2
4	**Nuclear Reactions**	Kinds of nuclear reactions, energetics of nuclear reactions, standard Q-equation and its solution, nuclear reaction cross-section, idea of differential cross-section, compound reaction mechanism and its verification – Ghoshal's experiment, Idea of pre-compound emission, direct reactions and their signatures. Introduction to Nuclear fission and fusion (qualitative), Source of energy in stars	8	CO2
5	**Nuclear Instrumentation**	**Particle accelerators:** Proton Synchrotron, Betatron, linear accelerator, Medical and industrial applications of accelerators. **Particle detectors:** Theory and working of G-M counter, Semiconductor detector and Cherenkov detector	7	CO3
6	**Particle Physics**	Concept of elementary particles and their classification: Families of Leptons, Mesons, Baryons and Baryon Resonances, Idea of Isospin, strangeness and hypercharge, Gell-Mann-Nishijima relation. Conservation of the different quantum numbers, Quark model of hadrons: quark flavours, confinement and QCD potential. Baryon decuplet and octet. Magnetic moments of baryons, Mass relations and splittings. Mesons built of light and heavy quarks.	8	CO3
7	**Symmetries in Particle physics**	Space reflection and parity, parity of charged pion, parity non-conservation in Beta decay, charge conjugation, time reversal, CPT theorem, symmetry and conservation rules.	6	CO4
8	**Introduction to standard model of particle physics**	Representation theory of SU(2) and SU(3) and its generators, preliminary idea of lie algebra, SU(3) flavour symmetry and construction of meson octet, baryon octet & decuplet and calculation of magnetic moments using their wave functions. A brief introduction to the electromagnetic, weak and strong interactions Gauge theory: Abelian gauge theory (QED) and its extension to non-abelian gauge theory. Electroweak unification, Higgs mechanism and spontaneous symmetry breaking. Neutrino Physics: Neutrino flavours, mass limits, helicity of neutrino, neutrino flavour oscillations. **(qualitative discussion only)**	8	CO4

Reference Books:

1. G.D. Coughlan and J.E. Dodd, *The Ideas of Particle Physics*
2. D. Griffiths, *Introduction to Elementary Particles*
3. D.H. Perkins, *Introduction to High Energy Physics*
4. I. Kaplan, *Nuclear Physics*
5. R.R. Roy and B.P. Nigam, *Nuclear Physics*
8. Kenneth S. Krane, "Introductory Nuclear Physics", Wiley India Private Limited, 2008
9. Bernard L. Cohen, "Concepts of Nuclear Physics", McGraw Hill, 2017
10. S.N. Ghoshal, "Nuclear Physics", S. Chand Publishing, 2019

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3					1	3	3		3	3	2	2
CO2	3					1	3	3		3	3	3	3
CO3	3					1	3	3		3	3	3	3
CO4	3					1	3	3		3	3	3	3

1- **Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

INTEGRAL UNIVERSITY

Effective from Session: 2025-26							
Course Code	B010804T/ PY421	**Title of the Course**	**Advanced Electronics**	**L**	**T**	**P**	**C**
Year	1st	**Semester**	2nd	**5**	**1**	**0**	**4**
Pre-Requisite	B.Sc. with Physics	**Co-requisite**					
Course Objectives	The objective of this course is to enable students to analyse electronic circuits using network theorems, understand semiconductor devices and amplifiers, design operational amplifier applications and regulated power supplies, and develop competency in power electronics, wave shaping, and switching circuits for practical and technological applications.						

Course Outcomes	
CO1	Analyze the complicated circuits by applying network theorems and examine the characteristics of various special purpose diodes
CO2	Analyze the functioning of various amplifiers and weigh their performance for different applications
CO3	Understand the working of regulated power supplies and interpret the application of SCR, Diac,Triac and UJT for power electronics applications
CO4	Judge the functioning of High Pass and Low Pass RC networks for various wave shaping applications
CO5	Examine the various multivibrators and Schmitt Trigger for switching applications

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Network Theorems and Semiconductor Junction**	Thevnin, Nortan and Superposition theorems and their applications, Brief about PN junction properties. Tunnel diode: junction formation, current characteristics and applications. Point contact diode: current characteristics and applications. Light emitting diodes: current characteristics, applications, limitation of silicon and germanium in LEDs. Photodiodes: I-V characteristics, applications, advantages & disadvantages. Thermistors: applications	8	CO1
2	**Amplifiers**	Difference Amplifiers; Broadband Amplifiers, Methods for achieving broad-banding; Emitter Follower at High Frequencies; Operational Amplifiers (OP Amp) and applications.	6	CO2
3	**Operational Amplifier Applications and Regulators**	OP Amp as inverting amplifier, effect of finite open loop gain, generalized basic equation of op amp with impedances, integrator and differentiator, inverting and non-inverting summer, voltage follower. Op Amp parameters, offset voltage and current, slew rate, full wave BW, CMRR. OP AMP as voltage regulator, fixed and variable 3 pin regulator, switching regulator	9	CO2
4	**Regulated Power Supplies**	Electronically Regulated Power Supplies; Converters and Inverters; High and Low Voltage Supplies, Application of SCR as Regulator; Switched-mode power supply (SMPS).	7	CO3
5	**Power Electronics**	SCR: Its operation, characteristics, SCR as Series Static switch, variable resistance phase controller, battery charging regulator, as a temperature controller, as emergency lighting system, as voltage sensor, as sawtooth generator, silicon controlled switch, light activated SCR, Shockley diode, Diac, Triac, UJT Characteristics	8	CO3
6	**Linear Wave Shaping 1**	High Pass and Low Pass RC Networks: Detailed Analysis; Response to Sinusoidal, Step, Pulse, Square wave, Exponential and Ramp Inputs; RC circuits applications;	7	CO4
7	**Linear Wave Shaping 2**	High pass RC circuit as a differentiator, Low Pass RC circuit as an Integrator; Criterion for good differentiation and integration. Laplace Transforms and their application to circuit elements.	7	CO4
8	**Switching Circuits**	Transistor as a Switch – Switching times: Definition and Derivation - Rise Time, Fall Time, Storage Time, Delay Time, Turn On Time, Turn Off Time Charge Control Analysis; Multi-vibrators: Astable, Monostable and Bistable; Schmitt Trigger	8	CO5

Reference Books:

1. Solid State Electronic Devices by B.G. Streetman
2. Electronic Devices and Circuit Theory by R.L. Boylested and L. Nashelsky
3. Integrated Electronics by J. Millman and C.C. Halkias
4. Introduction to Semiconductor Devices by M. S. Tyagi

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)												
PO-PSO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	3	1	2				3	2	3	1		3	1
CO2	3	1	2				3	2	3	1		2	1
CO3	3	2	2				2	2	2	1		2	1
CO4	3	1	1				2	1	2	2		3	1
CO5	3	2	2				3	3	3	2		3	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2025-26								
Course Code	B010805P/PY422	**Title of the Course**	Advanced Physics Lab II	**L**	**T**	**P**	**C**
Year	1st	**Semester**	2nd	**0**	**0**	**4**	**2**
Pre-Requisite	B.Sc. with Physics	**Co-requisite**					
Course Objectives	To provide hands-on experience in studying semiconductor, magnetic, nuclear, and electronic device characteristics through advanced experimental techniques.						

Course Outcomes	
CO1	Formulate physical interpretations of experimental data obtained from the Hall Effect, Four-Probe method, or GM counter to deduce semiconductor and nuclear properties such as carrier concentration, resistivity, or radiation laws.
CO2	Analyze the operational parameters and applications of Op-Amps, BJTs, and optical fibers to evaluate their performance in electronic circuits and communication systems effectively.

Experiment No.	**Title of the Experiment**	**Aim of the Experiment (*Offline)**	**Contact Hrs.**	**Mapped CO**
1	Hall effect	To study the Hall effect and determine the Hall coefficient, carrier concentration, and type of charge carriers in a given semiconductor material by measuring the Hall voltage as a function of magnetic field and current.	6	CO1
2	Four-Probe Method	To determine the resistivity of a given semiconductor sample using the Four-Probe method by measuring the voltage drop across the sample and the current through it.	6	CO1
3	Hysteresis (B-H Curve)	To trace the hysteresis loop (B-H curve) for a given ferromagnetic material using a transformer core and CRO, and to determine important magnetic parameters such as coercivity, retentivity, and saturation magnetization.	6	CO1
4	GM Counter (Geiger-Müller Counter)	To study the characteristics of a Geiger-Müller (GM) counter by plotting the plateau curve of count rate versus applied voltage, and to determine the optimum operating voltage range for stable operation.	6	CO1
5	GM Counter (Geiger-Müller Counter)	To verify the inverse square law, by measuring the variation in count rate with distance from a point radioactive source using a GM counter.	6	CO1
6	Op-Amp (Open Loop Gain)	To determine the open loop gain in a differential amplifier.	6	CO2
7	Op-Amp (CMRR)	To determine the Common Mode Rejection Ratio (CMRR) in a differential amplifier.	6	CO2
8	Op-Amp (Integrator and LPF)	To study the OP-Amp as integrator and to verify its working as Low Pass Filter.	6	CO2
9	BJT (CE and CB configurations)	To study the input and output characteristics of a BJT in CE and CB configurations and determine its input resistance, output resistance, and current gain using h-parameter.	6	CO2
10	Optical Fiber	To measure the propagation or attenuation loss in an optical fiber.	6	CO2

Reference Books:

1. **B.L. Worsnop, H.T. Flint**, *Advanced Practical Physics for Students*, Methuen & Co., Ltd., London, 1962, 9e.
2. **Indu Prakash, Ramakrishna**, *A Textbook of Practical Physics*, Kitab Mahal, Allahabad, 2020, 11e.
3. **G. L. Squires**, *Practical Physics*, Cambridge University Press, 2001, 4e.
4. **C.L. Arora**, *B.Sc. Practical Physics*, S. Chand Publishing, New Delhi, 2022, 20e.
5. **M. P. Srivastava**, *Advanced Practical Physics*, New Age International Publishers, 2001, 2e.
6. **D. Chattopadhyay, P.C. Rakshit**, *An Advanced Course in Practical Physics*, New Central Book Agency, Kolkata, 2022, Revised Edition.
7. **S. Panigrahi, B. Mallick**, *Engineering Practical Physics*, Cengage Learning India, 2015, 1e.
8. **K. G. Mazumdar, B. Ghosh**, *Exploratory Experiments in Physics*, University Press, 1999, 1e.
9. **K.K. Sharma**, *Instrumentation and Experimental Techniques in Physics*, PHI Learning Pvt. Ltd., New Delhi, 2005, 1e.
10. **S. Rajasekar, R. Chandrasekar**, *Quantum Mechanics and Modern Physics Experiments*, Pearson Education, 2011, 1e.

e-Learning Source:

1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74
2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities.

PO-PSO / CO	**Course Articulation Matrix: (Mapping of COs with POs and PSOs)**											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	3	--	--	--	--	--	2	3	2	3	--	--	--
CO2	3	--	--	--	--	--	2	3	--	3	--	2	--

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**