Kurukshetra University, Kurukshetra

(Established by the State Legislature Act-XII of 1956)

("A++" Grade, NAAC Accredited)

Syllabus
For
Post Graduate Programme

M.Sc. PHYSICS

as per NEP 2020
Curriculum and Credit Framework for Postgraduate Programme

With Multiple Entry-Exit, Internship and CBCS-LOCF
With effect from the session 2024-25 (in phased manner)

DEPARTMENT OF PHYSICS
FACULTY OF SCIENCE

KURUKSHETRA UNIVERSITY, KURUKSHETRA -136119

HARYANA, INDIA

240

Chairperson,
Department of Physics,
Kurukshetra University,
Kurukshetra-136 119.
(INDIA).

Session: 2024-25			
Part A - Introduction			
Name of Programme	M.Sc. Physics		
Semester	1^{st}		
Name of the Course	Mathematical Physics		
Course Code	M24-PHY-101		
Course Type	CC-I		
Level of the course	400-499		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 101.1:** Understand basics of group theory, preparation of group multiplication tables and construction of character table of symmetry groups. **CLO 101.2:** Find the Fourier series expansion, Fourier integrals, Fourier and Laplace transforms of functions and derivatives. **CLO 101.3:** Obtain explicit expressions of Hermite, Laguerre, Bessel and Legendre polynomials and to establish their recurrence relations and other properties. **CLO 101.4:** Derive Cauchy integral theorem, Cauchy integral formula, Taylor and Laurent series expansion of functions of complex variable and to evaluate some typical definite integral using the method of contour integration.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B- Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Group Theory**: Fundamentals of Group theory: Definition of a group and illustrative examples, Group multiplication table, rearrangement theorem, cyclic groups, sub-groups and cosets, permutation groups, conjugate elements and class structure, normal devisors and factor groups, isomorphism and homomorphism, class multiplication. Group representation: Reducible and irreducible representations, great orthogonality theorem (without proof) and its geometric interpretation,	15

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	character of a representation, construction of character table with illustrative examples of symmetry groups of equilateral triangle, rectangle and square. Decomposition of reducible representation, the regular representation. The elements of the group of Schrodinger equation.	
II	**Fourier Series and Integral Transforms:** Fourier series, General properties, Advantages and applications, Gibbs phenomenon, Development of the Fourier integral, Inversion theorem, Fourier transform, Fourier transform of derivatives, Momentum representation, Laplace transform, Laplace transform of derivative, Properties of Laplace transforms, Faltungs theorem, Inverse Laplace transformation.	15
III	**Special Functions**: Bessel Functions: Bessel functions of the first kind $J_n(x)$, Generating function, Recurrence relations, Expansion of $J_n(x)$ when n is half an odd integer, Integral representation; Legendre Polynomials $P_n(x)$: Generating function, Recurrence relations and special properties, Rodrigues' formula, Orthogonality of $P_n(x)$; Associated Legendre polynomials, Spherical harmonics, Addition theorem for spherical harmonics, Hermite and Laguerre Polynomials: generating function & recurrence relations only.	15
IV	**Functions of a complex variable and calculus of residues:** Complex algebra, Functions of a complex variable, Cauchy's integral theorem, Cauchy's integral formula; Taylor and Laurent expansions; Singularities; Cauchy's residue theorem, Cauchy principle value, Singular points and evaluation of residues, Jordan's Lemma; Evaluation of definite integrals of the type: $\int_0^{2\pi} f(\sin\theta, \cos\theta)\, d\theta$; $\int_{-\infty}^{\infty} f(x)dx$; $\int_{-\infty}^{\infty} f(x)e^{iax}dx$ using Cauchy's residue theorem.	15
	Total Contact Hours	60

Suggested Evaluation Methods

Internal Assessment: 30		**End Term Examination: 70**	
➢ **Theory**	30	➢ **Theory:**	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Group Theory and Quantum Mechanics by M. Tinkam.
2. Mathematical Methods for Physicists (4th edition) by G. Arfken.
3. Mathematical Methods for Physicists (6th edition) by Arfken and Weber.
4. Mathematical Physics for Physicists and Engineers by L. Pipes.
5. Introduction to Mathematical Physics by C. Harper.

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Session: 2024-25			
Part A - Introduction			
Name of Programme	M.Sc. Physics		
Semester	1st		
Name of the Course	Classical Mechanics		
Course Code	M24-PHY-102		
Course Type	CC-2		
Level of the course	400-499		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 102.1:** Demonstrate a basic and advanced knowledge of Lagrangian and Hamiltonian Formulations and solve related problems. Identify the cyclic coordinates and understand their importance in Hamiltonian formulation. **CLO102.2:** Acquire knowledge of canonical Transformation and various generating functions for this transformation. Develop a deep understanding to tackle the problems of classical mechanics under small oscillations. **CLO 102.3:** Demonstrate the concept of motion of a particle under central force and apply advanced methods to deal with central force problems. Use Hamilton-Jacobi theory for finding the solutions of various Classical systems. **CLO 102.4:** Understand the foundations of nonlinear dynamics in general and chaotic motion and fractals, in particular. Perform stability analysis of cubic anharmonic oscillator and undamped pendulum, and find chaotic trajectories.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B-Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions: selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Lagrangian and Hamiltonian formulations:** Hamilton's principle, Derivation of Lagrange's equations from Hamilton's principle, Principle of Least Action and its applications, Canonical Transformation; The Hamiltonian	15

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	Formalism: Canonical formalism, Hamiltonian equations of motion, The physical significance of the Hamiltonian, Cyclic coordinates, Rauthian procedure and equations, Derivation of Generating functions, examples, properties, Derivation of Hamiltonian equations from variational principle.	
II	**Poisson bracket and theory of small oscillations**: Poisson bracket, special cases of Poisson bracket, Poisson theorem, Poisson bracket and canonical transformation, Jacobi identity and its derivation, Lagrange bracket and its properties, the relationship between Poisson and Lagrange brackets and its derivation, the angular momenta and Poisson bracket, Liouville's theorem and its applications; Theory of small oscillations: Formulation of the problem, Eigenvalue equation and the principle axis transformation, frequencies of free vibrations and normal coordinates, free vibrations of a linear triatomic molecule.	15
III	**Two-body central force problem and H-J theory:** Two body central force problem: Reduction to the equivalent one body problem, the equation of motion and first integrals, classification of orbits, the Virial theorem, the differential equation for the orbit, integrable power law in time in the Kepler's problem, the Laplace-Runge-Lenz vector, scattering in central force field; H-J Theory: H-J equation and their solutions, use of H-J method for the solution of harmonic oscillator problem, Hamilton's principle function, Hamilton's characteristic function and their properties, Action angle variables for completely separable systems, the Kepler's problem in action angle variables.	15
IV	**Introductory non-linear dynamics:** Classical Chaos: Linear and nonlinear systems, periodic motion, Perturbation and KAM theorem, dynamics in phase space, phase portraits for conservative systems, attractors, classification and stability of equilibrium points, stability analysis of cubic anharmonic oscillator and undamped pendulum, chaotic trajectories and Liapunov exponent, Poincare Map, Henon-Hiels Hamiltonian, bifurcation, driven-damped harmonic oscillator, the logistic equation, Fractals and dimensionality.	15
	Total Contact Hours	60

Suggested Evaluation Methods

Internal Assessment: 30		End Term Examination: 70	
➢ **Theory**	30	➢ **Theory:**	**70**
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Classical Mechanics (3rd ed., 2002) by H. Goldstein, C. Poole and J. Safko, Pearson Edition
2. Classical Mechanics by John R Taylor.
3. Chaos and Integrability in nonlinear dynamics: An introduction (1989) by Michael Tabor.
4. Nonlinear dynamics: Integrability, Chaos and patterns (2003) by M. Lakshmanan and S. Rajasekar.
5. Classical Mechanics, J.C. Upadhyaya, Himalaya Publishing House.

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Session: 2024-25			
Part A–Introduction			
Name of Programme	M. Sc. Physics		
Semester	1st		
Name of the Course	Quantum Mechanics-I		
Course Code	M24-PHY-103		
CourseType	CC-3		
Level of the course	400-499		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	**CLO 103.1:** Realize basic quantum-mechanical view point, learn its wave mechanical & matrix formulations, and solve the Schrödinger equation for simple potentials, including harmonic and central potentials. **CLO 103.2:** Construct matrices for observables and wave functions in different representations, apply matrix theory to linear harmonic oscillator, and describe the time-development of a quantum system in Schrödinger, Heisenberg and Interaction pictures. **CLO 103.3:** Calculate the eigenvalues and eigen functions for the orbital and general angular momenta, learn the matrix representation of angular momentum, and perform addition of two angular momenta. **CLO 103.4:** Grasp the concepts of identity & indistinguishability, understand symmetric and anti-symmetric wave functions, construct spin and total wave functions for a system of two spin ½ particles, and comprehend connection among spin, symmetry & statistics.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B-Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The

question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Schrodinger formulation of Quantum Mechanics:** Recapitulation of basic concepts: Why quantum mechanics? Two-slit experiment with *em* radiation and matter particles, Quantum-mechanical view point, The Schrödinger wave equation, Expectation values, Ehrenfest theorem; Interpretative postulates of quantum mechanics: Dynamical variables as Hermitian operators, Eigenvalues and eigenfunctions, Expansion in eigenfunctions; Illustration of postulates for energy and momentum: Orthonormality of eigenfunctions, Reality of eigenvalues, Closure property, Probability function and expectation value, Co-ordinate and momentum representations of wave function, Uncertainty principle for two arbitrary observables; Problems: A charged particle in a uniform static magnetic field (eigenfunctions and Landau levels); The Hydrogen atom (reduced mass, radial wave functions and energy eigenvalues).	15
II	**Matrix formulation of Quantum Mechanics:** Preliminaries: Hermitian and unitary matrices, Transformation and diagonalization of matrices, Matrices of infinite rank; Representation of observables and wave functions as matrices, Transformation theory, choice of basis, change of basis, unitary transformations, Hilbert space representation; Dirac's ket and bra notation; Time-development of quantum system: Schrödinger, Heisenberg and Interaction pictures, Link with classical equations of motion, Quantization of a classical system; Application to motion of a particle in an *em* field; Matrix theory of the harmonic oscillator: Spectrum of eigenvalues and eigenfunctions, Matrices for position, momentum and energy operators (energy representation).	15
III	**Quantum theory of Angular Momentum:** Orbital angular momentum operator **L**, Cartesian and spherical polar co-ordinate representation, Commutation relations, Orbital angular momentum and spatial rotations, Eigenvalues and eigenfunctions of L^2 and L_z, Spherical harmonics; General angular momentum **J**: Eigenvalues and eigenfunctions of J^2 and J_z, Matrix representation of angular momentum operators, Spin angular momentum, Wave function including spin (Spinor); Spin one-half: Spin eigenfunctions, Pauli spin matrices; Addition of two angular momenta, Clebsch-Gordan coefficients and their calculation for $j_1 = j_2 = 1/2$, $j_1 = 1$, $j_2 = 1/2$ and $j_1 = j_2 = 1$; The Wigner-Eckart theorem.	15

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IV	**Many-particle systems and identical particles:** Many-particle Schrödinger wave equation, Stationary-state solutions; Systems of identical particles, Physical meaning of identity, Principle of indistinguishability, Exchange and transposition operators, Totally symmetric and anti-symmetric wave functions, Time-invariance of symmetry, Construction of symmetric and anti-symmetric wave functions, Connection among spin, symmetry and statistics of identical particles, Fermions and bosons; Spin and total wave functions for a system of two spin ½ particles, Pauli exclusion principle and Slater determinant; Application to the electronic system of the helium atom (*para*- and *ortho*-helium); Limit of distinguishability of identical particles; Basic idea of quantum entanglement.	15
	Total Contact Hours	60

Suggested Evaluation Methods

Internal Assessment: 30		End Term Examination: 70	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Quantum Mechanics (3rd edition) by L. I. Schiff
2. Quantum Mechanics (2nd edition) by B. H. Bransden and Joachain
3. Quantum Mechanics (3rd edition) by S. Gasiorowicz
4. Quantum Mechanics (3rd edition) by E. Merzbacher
5. Quantum Mechanics by John L. Powell and B. Crasemann
6. Quantum Mechanics by A. K. Ghatak and S. Loknathan
7. Introductory Quantum Mechanics (4rd edition) by Richard L. Liboff
8. Quantum Mechanics: Concepts and Applications (2nd edition) by N. Zettili
9. Quantum Mechanics by Y. B. Band and Y. Avishai

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Session: 2024-25			
Part A - Introduction			
Name of Programme	M.Sc. Physics		
Semester	1st		
Name of the Course	Electronic Devices and Circuits-I		
Course Code	M24-PHY-104		
CourseType	CC-4		
Level of the course	400-499		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 104.1:** Be aware of the general characteristics of important semiconductor materials. Develop a deep understanding of the basic design, operation and characteristics of a pn-junction and a BJT along with knowledge of the basic network theorems and their applications in electronic circuit analysis. **CLO 104.2:** Learn to devise and analyze various transistor amplifier models. Understand the concept of negative feedback and its importance in amplifiers. **CLO 104.3:** Perform a load-line analysis and design of various biasing schemes in amplifiers. Acquaint with the frequency response of variously coupled amplifiers and sources of noise in electronic devices. **CLO 104.4:** Gain knowledge of classification, sources of distortions and their estimation, operation and determination of efficiency of power amplifiers. Clearly understand the need of regulation, operation and circuit analysis of different voltage and current regulators.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B-Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact

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		Hours
I	**Basics of pn-junction, BJT and Network Theorems:** Semiconductors: intrinsic and extrinsic semiconductors, charge densities in p and n type semiconductors, conduction by charge drift and diffusion, the pn-junction, energy level diagrams of pn-junction under forward and reverse bias conditions, derivation of pn-diode equation, Zener diode,Zener and avalanche breakdowns, clipping and clamping circuits; The bipolar junction transistor: basic working principle, configurations and characteristics, voltage breakdowns. Network theorems: node, mesh, superposition, Miller's, Thevenin's and Norton's theorems.	15
II	**Amplifier Models, Feedback and Biasing:** Two port network analysis: active circuit models, gain in decibels, equivalent circuit for BJT, the transconductance model for BJT, analysis of CE, CB, and CC amplifiers; An amplifier with feedback, effect of negative feedback on gain and its stability, distortions, input and output impedances of amplifiers, Location of quiescent (Q) point, biasing circuits for amplifiers: fixed bias, emitter feedback bias & voltage feedback bias, bias compensation, bias techniques for linear integrated circuits, thermal runaway and thermal stability.	15
III	**Frequency Response of Amplifiers:** The amplifier pass band, mid frequency range response of a direct coupled CE cascade, the high frequency equivalent circuit (Miller effect), the high frequency response of a direct coupled CE cascade, the frequency response of RC and transformer coupled CE amplifiers, gain-frequency plots of amplifier response (Bode plots), bandwidth of cascaded amplifiers, bandwidth criterion for the transistor, the gain-bandwidth product, composite amplifier designs, bootstrapping in amplifiers, noise in amplifiers, noise figure.	15
IV	**Power Amplifiers and Regulators:** Power amplifiers: class A large signal amplifier, second and higher order harmonic distortions, the transformer coupled power amplifier, impedance matching, efficiency, push-pull amplifiers, class-B amplifiers, complementary stages, cross over distortions, class-AB operation, heat sinks, derating curve; Electronic voltage regulators: basic operation and analysis of Zener diode voltage regulator, single BJT shunt and series regulators, feedback series BJT regulator and current regulator, overload and short circuit protection circuits.	15
	Total Contact Hours	60

Suggested Evaluation Methods

Internal Assessment: 30		End Term Examination: 70	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Electronic fundamentals and applications (5^{th} Ed.) by J. D. Ryder.
2. Integrated Electronics by J. Millman and C. C. Halkias.
3. Circuits and Networks: Analysis and Synthesis by A. Sudhakar and S.M.S. Palli
4. Electronic devices and circuits by Y. N. Bapat.
5. Pulse, digital and switching waveforms by J. Millman and H. Taub.
6. Millman's Electronic Devices and Circuits by J. Millman, C. C. Halkias & SatyabrataJit

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7. Electronic Devices and Circuit Theory by Robert L Boylestad and Louis Nashelsky.
8. Solid state Electronic Devices by B.G. Streetman and S.K. Banerjee.

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Session: 2024-25

Part A- Introduction

Name of the Programme	M.Sc. Physics
Semester	1st
Name of the Course	Physics Lab-I
Course Code	M24-PHY-105
Course Type	PC-1
Level of the course	400-499
Pre-requisite for the course (if any)	--
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 105.1:** Draw and understand the frequency response of different Filter circuits and a RC-coupled amplifier in its three configurations. Also measure important parameters of rectifier, filter, voltage regulator and pn-junction circuits. **CLO 105.2**: Design and draw load characteristics of a push-pull amplifier **CLO 105.3:** Design and understand the operations of clipping, clamping circuits, differentiating and integrating circuits. **CLO 105.4:** Measure the sensitivities of X and Y plates of a CRO and determine frequency and phase-difference using a CRO.

	Theory	Practical	Total
Credits	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	

Part B- Contents of the Course

Practicals	**Contact Hours**
Note: Student will perform at least six experiments. The examiner will allot one practical at the time of end term examination. 1. To determine various parameters of a pn-junction diode. 2. To study the frequency response of low-pass, high-pass and band-pass filters. 3. To study the rectifier circuits and to measure the ripple factors of C, L and π-section filters. Also study the stabilization characteristics of a voltage regulator consisting of IC-741. 4. To study the load characteristics of a Class-B push-pull amplifier. 5. To draw frequency response characteristics of a RC-coupled single stage BJT amplifier in all the three configurations. 6. To measure (a) phase difference, (b) deflection sensitivities and (c) frequency of an unknown ac signal using CRO. 7. To study the clipping and the clamping circuits. 8. To study the differentiating and integrating circuits.	120

Suggested Evaluation Methods

Internal Assessment: 30	**End Term Examination: 70**

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➢ **Practicum**	**30**	➢ **Practicum**	**70**
• Class Participation:	5	Lab record, Viva-Voce, write-up and execution of the practical	
• Seminar/Demonstration/Viva-voce/Lab records etc.:	25		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Integrated Electronics by J. Millman and C. C. Halkias
2. Pulse, digital and switching waveforms by J. Millman and H. Taub
3. Electronic devices and circuits by Y. N. Bapat
4. Microwave devices and circuits by Samuel Y. Liao
5. Physics of semiconductor Devices by S. M. Sze
6. Electronic instrumentation and measurement techniques by W. D. Cooper and A. D. Helfrick
7. OPAMPs and linear IC circuits by Ramakant A. Gayakwad
8. Electronics for Scientists and Engineers: Devices, Circuits and Systems by TV Viswanathan, GK Mehta and V Rajaraman

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Session: 2024-25			
Part A - Introduction			
Name of the Programme	M.Sc. Physics		
Semester	1^{st}		
Name of the Course	Physics Lab-II		
Course Code	M24-PHY-106		
Course Type	PC-2		
Level of the course	400-499		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 106.1:** Determine the ionization potential of mercury. Measure the width of a narrow slit using diffraction phenomenon. Calculate the Planck's constant using a suitable light source. **CLO 106.2:** Set Fabry-Parot interferometers for various practical measurements. Verify the energy quantization using the Frank-Hertz Experiment. **CLO 106.3:** Demonstrate different harmonics present in complex signals using Fourier Analysis. Verify the inverse square law of radiation flux. **CLO 106.4:** Measure the band gap of a semiconductor material. Understand the underlying dynamics mimicked by the Chua' and Feigenbaum circuits.		
Credits	Theory	Practical	Total
	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	

Part B- Contents of the Course

Practicals	Contact Hours
Note: Student will perform at least six experiments. The examiner will allot one practical at the time of end term examination. 1. To determine the ionization potential of mercury. 2. To measure the width of a narrow slit using the diffraction phenomenon. 3. To determine the value of Planck's constant using photocell/LED. 4. Fabry-Parot interferometer experiment. 5. Demonstration of energy quantization using the Frank-Hertz Experiment. 6. Fourier analysis of complex signals 7. To determine band-gap of a semiconductor material. 8. To verify the inverse square law of radiation flux. 9. To study nonlinear dynamics using Chua' circuit. 10. To study nonlinear dynamics using Feigenbaum circuit.	120

Suggested Evaluation Methods

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Internal Assessment: 30		End Term Examination: 70	
➢ Practicum	30	➢ Practicum	70
• Class Participation:	5	Lab record, Viva-Voce, write-up and execution of the practical	
• Seminar/Demonstration/Viva-voce/Lab records etc.:	25		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Integrated Electronics by J. Millman and C. C. Halkias
2. Nonlinear dynamics: Integrability, Chaos and patterns (2003) by M. Lakshmanan and S. Rajasekar
3. Introduction to Solid State Physics (7th edition) by Charles Kittel
4. Modern Physics by Arthur Beiser
5. Elements of Nuclear Physics by W. E. Meyerhof.
6. Nuclear Radiation Detectors by S. S. Kapoor and V. S. Ramamurthy.

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Session: 2024-25			
Part A - Introduction			
Subject	Physics		
Semester	1st		
Name of the Course	Seminar		
Course Code	M24-PHY-107		
CourseType: (CC/MCC/MDC/CC-M/ DSEC /VOC/DSE/PC/AEC/VAC)	Seminar		
Level of the course (As per Annexure-I	400-499		
Pre-requisite for the course (if any)	NA		
Course Learning Outcomes(CLO):	**CLO 107.1:** Achieve effective communication skills and understand the concepts involved in the topic of seminar. **CLO 107.2:** Acquire skills for working in team and develop confidence for facing audience. **CLO 107.3:** Learn to write effectively a report on a particular topic and know the techniques of responding to the questions posed by audience. **CLO 107.4:** Enhance the presentation abilities and improve interpersonal skills.		
Credits	Theory	Practical	Total
	2	1	3
Contact Hours	2	2	4

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Session: 2024-25			
Part A - Introduction			
Name of Programme	M. Sc. Physics		
Semester	2nd		
Name of the Course	Nuclear and Particle Physics		
Course Code	M24-PHY-201		
Course Type	CC-5		
Level of the course	400-499		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	**CLO 402.1:** Understand the energy loss processes of different energetic particles in a medium and mechanisms of interaction of gamma photon with matter and Learn about the basic properties and characteristics of Nuclear forces, and their mediating particle. **CLO 402.2:** Know and learn about various type of detectors used in nuclear physics experiments, unique properties of different detectors and their applications in the field of nuclear physics and Differentiate between different type of nuclear reactions, relevant aspects associated with nuclear reactions and kinematics of such reactions. **CLO 402.3:** Describe certain properties associated with nuclei, models governing different aspects of nuclear behaviour and detailed understanding of deuteron problem and understand the phenomenon of radioactive decays of alpha and beta particles, their detailed formalism. **CLO 402.4:** Know about different elementary particles, their quark content and quark model and Learn about decay of some elementary particles and laws governing such decays.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

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Part B- Contents of the Course		
Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.		
Unit	**Topics**	**Contact Hours**
I	**Radiation Interaction and Nuclear Forces:** Interaction of Charged Particles with Matter: qualitative description of various energy loss mechanisms, their relative contribution in case of heavy ions and electrons, classical stopping power equation for electronic energy-loss (no derivation) with significance of various terms involved, behavior of electronic energy-loss curve as a function of ion velocity, concept of energy straggling and range straggling and their correlation; Interaction of Gamma Radiation with Matter: features of photoelectric, Compton and pair production processes, Nuclear Forces: experimental evidence of charge symmetry and charge independence of nuclear forces, concept of isospin, Meson theory of nuclear forces, relationship between the range of the force and mass of the mediating particle.	15
II	**Radiation Detectors and Nuclear Reactions:** Gamma Ray Spectrometer: basic principle and working of NaI (Tl) scintillation detector, mechanism of pulse formation, basic idea of pulse processing unit, concept of energy resolution and efficiency of detector and its applications; Semiconductor Detectors: basic principle, construction and working and applications of Si surface barrier detector, high purity germanium detector. Nuclear Reactions: types of nuclear reactions, Q-value of a nuclear reaction and its determination, definition of cross section and its significance, elementary idea of compound nuclear reactions and direct reactions. Concept of neutron detection, Coulomb excitation, nuclear kinematics.	15
III	**Nuclear Properties and Radioactive Decays:** Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semi-empirical mass formula, liquid drop model, Deuteron problem; Ground state of deuteron, Magnetic moment and its importance in the determination of exact ground state of deuteron. Radioactive Decays: energetics of alpha decay, tunnel theory of alpha decay, energetics of beta decay, Fermi theory of allowed beta decay, importance of Fermi-Kurie plot, parity non-conserving property of neutrino;	15
IV	**Particle Physics:** Units in high energy physics; Classification of particles- fermions and bosons, particles and antiparticles; Strange particles, Basic idea of different fundamental types of interactions with suitable examples; Quark flavors and their quantum numbers, Quarks as constituents of Hadrons, Qualitative idea of Quark confinement and asymptotic freedom, necessity of introducing the Color quantum no., Quark model, decay of pion and muon, Gell-Mann Nishijima formula,	15

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conservation laws.			
		Total Contact Hours	60
Suggested Evaluation Methods			
Internal Assessment: 30		End Term Examination: 70	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Introduction to Experimental Nuclear Physics by R. M. Singru.
2. Elements of Nuclear Physics by W. E. Meyerhof.
3. Nuclear Radiation Detectors by S. S. Kapoor and V. S. Ramamurthy
4. Introduction to High Energy Physics (2nd edition) by D. H. Perkins.
5. Radiation Detection and Measurement by G. F. Knoll.
6. Nuclear Physics Theory and Experiment, by R. R. Roy and B. P. Nigam.

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Session: 2024-25			
Part A–Introduction			
Name of Programme	M. Sc. Physics		
Semester	2^{nd}		
Name of the Course	Solid State Physics		
Course Code	M24-PHY-202		
Course Type	CC-6		
Level of the course	400-499		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	**CLO 202.1:** Analyze the structure of a crystalline solid in terms of lattice, basis and unit cell, and of a non-crystalline solid on the basis of pair-distribution function and deduce the structure of a crystalline solid from the XRD pattern. **CLO 202.2:** Calculate the dispersion of lattice waves for crystals with mono- and diatomic basis, and acquire an understanding of phonon and use it to determine the lattice heat capacity in the Einstein and Debye models. **CLO 202.3:** Learn the Bloch's theorem, solve the KP model & one-electron Schrödinger equation for a periodic potential, classify materials into conductors, semiconductors and insulators, and apply the tight binding & Wigner-Seitz methods for calculation of energy bands. **CLO 202.4:** Grasp main characteristics of superconductors, along with qualitative aspects of the BCS theory, explain flux quantization in a superconducting ring, and the DC & AC Josephson effects.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B- Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory

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question. All questions will carry equal marks.		
Unit	**Topics**	**Contact Hours**
I	**Crystal Structure:** Recapitulation of basic concepts: Bravais lattice and Primitive vectors; Primitive, Conventional and Wigner-Seitz unit cells; Crystal structures and lattices with bases: Symmetry operations and fundamental types of lattices; Index system for crystal planes. Determination of crystal structure by X-ray diffraction: Reciprocal lattice and Brillouin zones (examples of *sc*, *bcc* and *fcc* lattices); Bragg and Laue formulations of X-ray diffraction by a crystal and their equivalence; Laue equations; Ewald construction; Brillouin interpretation; Crystal and atomic structure factors; Structure factor of the *bcc* and *fcc* lattices. Examples of NaCl and diamond; Experimental methods of structure analysis: Types of probe beam, The Laue, rotating crystal and powder methods. Non-crystalline solids: Diffraction pattern; Monatomic amorphous materials; Pair-distribution function.	15
II	**Lattice dynamics and thermal properties:** Binding in solids: Crystals of inert gases, Van der Waals-London interaction, Repulsive interaction, Lennard-Jones potential, Equilibrium lattice constants, Cohesive energy; Qualitative idea of Ionic, Covalent and Metallic binding. Classical theory of lattice vibration (in harmonic approximation): Vibrations of crystals with monatomic basis- Dispersion relation, First Brillouin zone, Group velocity; Two atoms per primitive basis- dispersion of acoustical and optical modes. Quantization of lattice waves: Phonons, Phonon momentum, Inelastic scattering of neutrons by phonons. Thermal properties: Lattice (phonon) heat capacity; Normal modes; Density of states in one and three dimensions; Models of Debye and Einstein, Debye T^3 law; Effects due to anharmonic crystal interactions; Thermal expansion; Thermal conductivity.	15
III	**Electronic properties of solids:** Sommerfeld's free electron gas model, Density of states, Fermi sphere, Fermi and ground-state energy; Difficulties with the free electron gas model; Band theory of solids: Nearly free electron model, Origin and magnitude of the energy gap; Periodic potential and Bloch's theorem: Kronig-Penney model; Wave equation of electron in a periodic potential, Central equation, Crystal momentum of electron, Solution of the central equation, Approximate solution at and near a zone boundary; Periodic, extended and reduced zone schemes of energy band representation; Number of orbitals in a band; Classification into metals, semiconductors and insulators. Calculation of energy bands: Tight binding method and its application to *sc*, *bcc* and *bcc* structures; Wigner-Seitz method, Cohesive energy; Pseudo-potential methods (qualitative idea).	15
IV	**Superconductivity:** Experimental survey: Superconductivity and its occurrence, Destruction of superconductivity by magnetic fields, Meissner effect, Type I and type II superconductors, Entropy, Free energy, Heat capacity, Energy gap, Microwave and infrared properties, Isotope effect; Theoretical survey: Thermodynamics of the superconducting	15

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	transition, London equation, London penetration depth, Coherence length; Microscopic theory: Qualitative features of the BCS theory, BCS ground state wave function; Quantitative predictions of the BCS theory, critical temperature, energy gap, critical field, specific heat; Flux quantization in a superconducting ring, duration of persistent currents; Dc and Ac Josephson effects: Macroscopic long-range quantum interference; High T_c superconductors (introduction only).	
	Total Contact Hours	60

Suggested Evaluation Methods			
Internal Assessment: 30		**End Term Examination: 70**	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Introduction to Solid State Physics (7th edition) by Charles Kittel
2. Solid State Physics by Neil W. Ashcroft and N. David Mermin
3. Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth
4. Principles of the Theory of Solids (2nd edition) by J. M. Ziman
5. Condensed Matter Physics by Michael P. Marder
6. Applied Solid State Physics by Rajnikant

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Session: 2024-25			
Part A - Introduction			
Name of Programme	M. Sc. Physics		
Semester	2nd		
Name of the Course	Quantum Mechanics-II		
Course Code	M24-PHY-203		
Course Type	CC-7		
Level of the course	400-499		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	**CLO 203.1:** Formulate perturbation, variational & WKB methods for obtaining approximate solutions of the Schrödinger equation, and comprehend simple physical effects: Zeeman & Stark effects & alpha decay. **CLO 203.2:** Apply the time-dependent perturbation theory to deal with atom-em radiation interaction and calculate explicitly the transition probability for induced absorption and emission. **CLO 203.3:** Explicate electronic structure of many-electron atoms in central-field approximation, estimate the central potential using the Thomas-Fermi & Hartree methods, and have an understanding of molecular energy levels. **CLO 203.4:** Grasp the basics of quantum scattering theory, learn the partial waves and Green's function methods for deriving scattering cross-sections, and calculate these for finite square well, hard sphere & screened Coulomb potentials.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B-Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

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Unit	Topics	Contact Hours
I	**Approximate methods for bound states-I:** Stationary perturbation theory: Non-degenerate case- First-order and second-order corrections to energy eigenvalues and eigenfunctions. Perturbation of an oscillator (harmonic and anharmonic ($ax^3 + bx^4$) perturbations). Ground state of Helium atom; Degenerate case- Removal of degeneracy in first and second order, Zeeman effect without electron spin, First-order Stark effect in n=2 state of Hydrogen. Fine structure of hydrogen atom (Relativistic and spin-orbit coupling corrections); Rayleigh-Ritz variational method: Ground and excited states. Application to ground state of Helium, Van der Waals interaction using perturbation and variational methods.	15
II	**Approximate methods for bound states-II:** The WKB approximation: Classical limit, Approximate solutions, Asymptotic nature of the solutions, Solution near a turning point, Linear turning point, Connection at the turning point, Asymptotic connection formulae, Application to energy levels of a quantum well, tunneling through a potential barrier and alpha decay; First-order time-dependent perturbation theory, Transition probability for constant and harmonic perturbations, Transition to a group of final states- The Fermi golden rule, Applications: Ionization of a hydrogen atom, Ionization probability, Interaction of an atom with *em* radiation (semi-classical treatment), Transition probability for induced absorption and emission, perturbation theory in scattering problems.	15
III	**Selected applications of Quantum Mechanics:** Atomic structure of many-electron atoms: Central-field approximation, Periodic system of elements, Thomas-Fermi statistical model, Evaluation of the potential, Hartree's self-consistent fields and connection with the variational method, Corrections to the central-field approximation, L-S and j-j couplings; Molecular structure: Classification of energy levels, Wave equation; The Hydrogen molecule: Potential energy function, The Morse potential, Rotation and vibration of diatomic molecules, Energy levels.	15
IV	**Quantum theory of scattering:** Scattering experiments and cross-sections, The laboratory and center-of-mass systems, Scattering amplitude and cross-section; The method of partial waves: Phase shift, Differential and total cross-sections, Relation between phase shift and scattering potential, Convergence of the partial-wave series, Scattering by a finite square well, Resonances- Breit-Wigner formula, Scattering by a hard-sphere potential; Green's function method: Lippmann-Schwinger equation, The Born series, The first Born approximation, Scattering of an electron by a screened Coulomb potential in Born approximation and validity criterion; Scattering of two identical spinless bosons, and spin-1/2 fermions.	15
	Total Contact Hours	60
	Suggested Evaluation Methods	

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Internal Assessment: 30		End Term Examination: 70	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		
Part C-Learning Resources			

Recommended Books/e-resources/LMS:

1. Quantum Mechanics (3rd edition) by L. I. Schiff
2. Quantum Mechanics (2nd edition) by B. H. Bransden and Joachain
3. Introduction to Quantum Mechanics (2nd edition) by David J. Griffiths
4. Quantum Mechanics by A. K. Ghatak and S. Loknathan
5. A Textbook of Quantum Mechanics by P. M. Mathews and K. Venkatesan
6. Quantum Mechanics by John L. Powell and B. Crasemann
7. Quantum Mechanics: Concepts and Applications (2nd edition) by N. Zettili

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Session: 2024-25			
Part A - Introduction			
Name of Programme	M.Sc. Physics		
Semester	2nd		
Name of the Course	Electronic Devices and Circuits-II		
Course Code	M24-PHY-204		
Course Type	CC-8		
Level of the course	400-499		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 204.1:** Well acquainted with the basic structures, operations, characteristics and biasing schemes of various field effect transistors. Understand the operations of different multivibrator circuits. **CLO 204.2:** Develop a clear understanding of the basics of OPAMPS, its operating modes, internal structure and its vital design parameters. Become familiar with the basic structure, operation, characteristics and important applications of negative resistance devices. **CLO 204.3:** Design and describe the operations of various families of logic gates. Simplify involved Boolean expressions with the help of Boolean algebra and K-map. **CLO 204.4:** Explain the construction, operation, characteristics and important technological applications of various photonic devices. Explain the construction, operation, characteristics and important technological applications of different temperature sensitive devices.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B-Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory

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question. All questions will carry equal marks.		
Unit	**Topics**	**Contact Hours**
I	**Field Effect Transistors and Multivibrators:** Basic structure and operation of JFET, calculation of pinch off voltage, V-I characteristics of JFET, the FET small signal model, metal oxide semiconductor field effect transistor (MOSFET), physical structure, operation and characteristics, enhancement and depleted modes of operation, metal semiconductor field effect transistor (MESFET), low frequency common source and common drain FET amplifiers, FET biasing, FET as a voltage variable resistor (VVR); Multivibrators: a fixed biased transistor, a self-biased transistor and a direct connected bistable multivibrator circuits, Schmitt trigger circuit, triggering techniques for bistable multivibrators, collector-coupled and emitter-coupled monostable and astable multivibrators.	15
II	**OPAMPs and Negative Resistance Devices:** The basic OPAMP, inverting and non-inverting mode of operation of OPAMP, effect of negative feedback on input and output resistances of OPAMPs, the differential amplifier, common mode rejection ratio (CMRR), the emitter coupled differential amplifier, the transfer characteristics of a differential amplifier, an IC OPAMP (MC-1530 Motorola) and its dc analysis, offset voltages and currents, universal balancing techniques, measurement of OPAMP parameters; basic working principles, characteristics and applications of uni-junction transistor (UJT), four layer diode (pnpn-diode), tunnel diode and silicon controlled rectifier.	15
III	**Digital Circuits:** Digital (binary) operation of a system, logic systems, the OR gate, the AND gate, the NOT gate, the exclusive OR gate, De Morgan's laws, Boolean algebra, the NAND and NOR diode-transistor gates, Modified DTL gates, fan-in and fan-out, wired logics, high threshold logic (HTL) gates, transistor- transistor logic (TTL) gates, output stages for TTL gates, resistance-transistor logic (RTL) gates, direct coupled transistor logic (DCTL) gates, emitter coupled logic (ECL) gates, digital MOSFET circuits, complementary MOS (CMOS) logic gates, comparison of logic families, Karnaugh- map (K-map) up to four variable and its applications.	15
IV	**Optoelectronic and Temperature Sensing Devices:** Radiative and nonradiative transitions, basic construction, operation, characteristics and applications of solar cells, light dependent resistance (LDR), photodiodes, p-i-n diodes, metal semiconductor photodiodes, avalanche photodiodes, light emitting diodes (LEDs), semiconductor diode lasers, photo transistors, resistance thermometers, thermocouples and thermistors.	15
	Total Contact Hours	60

Suggested Evaluation Methods			
Internal Assessment: 30		**End Term Examination: 70**	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	

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• Seminar/presentation/assignment/quiz/class test etc.:	10	
• Mid-Term Exam:	15	

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Integrated Electronics by J. Millman and C. C. Halkias
2. Pulse, digital and switching waveforms by J. Millman and H. Taub
3. Electronic devices and circuits by Y. N. Bapat
4. Microwave devices and circuits by Samuel Y. Liao
5. Physics of semiconductor Devices by S. M. Sze
6. Electronic instrumentation and measurement techniques by W. D. Cooper and A. D. Helfrick
7. OPAMPs and linear IC circuits by Ramakant A. Gayakwad
8. Electronics for Scientists and Engineers: Devices, Circuits and Systems by TV Viswanathan, GK Mehta and V Rajaraman

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Session: 2024-25			
Part A - Introduction			
Name of the Programme	M.Sc. Physics		
Semester	2nd		
Name of the Course	Physics Lab-III		
Course Code	M24-PHY-205		
Course Type	PC-3		
Level of the course	400-499		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 205.1:** Draw V-I characteristics of an UJT and also able to design and able to determine the frequency of saw-tooth waves using UJT. **CLO 205.2:** Design and draw load characteristics of a push-pull amplifier and design and verify truth tables of the basic logic gates. **CLO 205.3:** Design and understand the operations of astable multivibrator. Also draw the characteristics of various opto-electronic devices. **CLO 205.4:** Explain the FET as VVR, the V-I characteristics of an emitter coupled differential amplifier, pnpn-diode and thermistor.		
	Theory	Practical	Total
Credits	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	

Part B-Contents of the Course

Practicals	Contact Hours
Note: Student will perform at least six experiments. The examiner will allot one practical at the time of end term examination. 1. To draw the V-I characteristics of a Uni-Junction Transistor. 2. To generate saw-tooth waves using UJT and find its frequency. 3. To design circuits for OR, AND, NOT, NAND and NOR logic gates and verify their truth tables. 4. To study the astable multivibrator. 5. To draw characteristics of opto-electronic devices. 6. To study a FET as voltage variable resistance (VVR). 7. To draw transfer characteristics of an emitter-coupled BJT differential amplifier. 8. To draw characteristics of a negative resistance thermistor	120

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	9. To draw the V-I characteristics of a pnpn-diode. 10. To generate square waves using a Schmitt's trigger circuit.	

Suggested Evaluation Methods

Internal Assessment: 30		End Term Examination: 70	
➢ Practicum	30	➢ Practicum	70
• Class Participation:	5	Lab record, Viva-Voce, write-up and execution of the practical	
• Seminar/Demonstration/Viva-voce/Lab records etc.:	25		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Integrated Electronics by J. Millman and C. C. Halkias
2. Pulse, digital and switching waveforms by J. Millman and H. Taub
3. Electronic devices and circuits by Y. N. Bapat
4. Microwave devices and circuits by Samuel Y. Liao
5. Physics of semiconductor Devices by S. M. Sze
6. Electronic instrumentation and measurement techniques by W. D. Cooper and A. D. Helfrick
7. OPAMPs and linear IC circuits by Ramakant A. Gayakwad
8. Electronics for Scientists and Engineers: Devices, Circuits and Systems by TV Viswanathan, GK Mehta and V Rajaraman

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Session: 2024-25			
Part A - Introduction			
Name of the Programme	M.Sc. Physics		
Semester	2^{nd}		
Name of the Course	Physics Lab-IV		
Course Code	M24-PHY-206		
Course Type	PC-4		
Level of the course	400-499		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 206.1:** Calculate the Planck's constant using a suitable light source and half life of Indium. **CLO 206.2:** Measure the mass absorption coefficient of β-rays in Aluminum and the band gap of a semiconductor. Set Michelson interferometer for various practical measurements **CLO 206.3:** Determine the strength of α-source and verify nuclear statistics using SSNTD. **CLO 206.4:** Determine the specific heat of a given solid specimen and the thermoelectric voltage as a function of the temperature differential. Study of Dia-, para- and ferromagnetic materials in an inhomogeneous magnetic field.		
Credits	Theory	Practical	Total
	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	

Part B- Contents of the Course

Practicals	Contact Hours
Note: Student will perform at least six experiments. The examiner will allot one practical at the time of end term examination. 1. To study absorption of β-rays in Aluminum. 2. Michelson interferometer experiment. 3. To determine the half-life of Indium. 4. To determine the strength of an α-source using SSNTD. 5. To study nuclear statistics using SSNTD. 6. To determine band-gap of a semiconductor material. 7. To determine the specific heat of a given solid specimen. 8. Seeback effect: Determining the thermoelectric voltage as a function of the temperature differential.	120

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	9. Dia-, para- and ferromagnetic materials in an inhomogeneous magnetic field.	

Suggested Evaluation Methods

Internal Assessment: 30		End Term Examination: 70	
➢ Practicum	30	➢ Practicum	70
• Class Participation:	5	Lab record, Viva-Voce, write-up and execution of the practical	
• Seminar/Demonstration/Viva-voce/Lab records etc.:	25		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Introduction to Experimental Nuclear Physics by R. M. Singru.
2. Elements of Nuclear Physics by W. E. Meyerhof.
3. Nuclear Radiation Detectors by S. S. Kapoor and V. S. Ramamurthy
4. Introduction to High Energy Physics (2nd edition) by D. H. Perkins.
5. Radiation Detection and Measurement by G. F. Knoll.
6. Nuclear Physics Theory and Experiment, by R. R. Roy and B. P. Nigam.
7. Introduction to Solid State Physics (7th edition) by Charles Kittel
8. Solid State Physics by Neil W. Ashcroft and N. David Mermin.

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Session: 2024-25			
Part A - Introduction			
Name of the Programme	Common to all PG Programmes		
Semester	2nd		
Name of the Course	Constitutional, Human and Moral Values, and IPR		
Course Code	M24-CHM-201		
Course Type	CHM		
Level of the course	400-499		
Pre-requisite for the course (if any)	---		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 1.1:** Learn the different Constitutional Values, Fundamental rights and duties enshrined in the India Constitution. **CLO 1.2:** Understand humanism, human virtues and values, and idea of International peace. **CLO 1.3:** Grasp the basic concepts of Moral Values and Professional Conduct which are required to become a part of the civil society and for developing professionalism. **CLO 1.4:** Understand concepts of Intellectual Property Rights, Copyright, Patent, Trademark etc.. and about threats of Plagiarism.		
	Theory	Practical	Total
Credits	2	0	2
Teaching Hours per week	2	0	2
Internal Assessment Marks	15	0	15
End Term Exam Marks	35	0	35
Max. Marks	50	0	50
Examination Time	3 hours		

Part B-Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Constitutional Values:** Historical Perspective of Indian Constitution; Basic Values enshrined in the Preamble of the Indian Constitution; Concept of Constitutional Morality; Patriotic Values and Ingredients Nation Building; Fundamental Rights and Duties ; Directive Principles of the State Policy.	8
II	**Humanistic Values:** Humanism, Human Virtues and Civic Sense; Social Responsibilities of Human Beings; Ethical ways to deal with human	7

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	aspirations; Harmony with society and nature; Idea of International Peace and Brotherhood (Vasudhaiv Kutumbkam).	
III	**Moral Values and Professional Conduct:** Understanding Morality and Moral Values; Moral Education and Character Building; Ethics of Relations: Personal, Social and Professional; Introduction to Gender Sensitization; Affirmative approach towards Weaker Sections (SCs, STs, OBCs, EWS& DAs); Ethical Conduct in Higher Education Institutions; Professional Ethics.	8
IV	**Intellectual Property Rights:** Meaning, Origins and Nature of Intellectual Property Rights (IPRs);Different Kinds of IPRs – Copyright, Patent, Trademark, Trade Secret/Dress, Design, Traditional Knowledge; Infringement and Offences of IPRs – Remedies and Penalties; Basics of Plagiarism policy of UGC.	7
	Note: Scope of the syllabus shall be restricted to generic and introductory level of mentioned topics.	
	Total Contact Hours	30

Suggested Evaluation Methods

Internal Assessment: 15		End Term Examination: 35	
➢ Theory	15	➢ Theory	35
• Class Participation:	4	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	4		
• Mid-Term Exam:	7		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Ahuja, V K. (2017). *Law relating to Intellectual Property Rights*, India, IN: Lexis Nexis.
2. Bajpai, B. L., *Indian Ethos and Modern Management*, New Royal Book Co., Lucknow, 2004.
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11. Narayanan, P, *IPRs*.
12. Neeraj, P., & Khusdeep, D. (2014). *Intellectual Property Rights*, India, IN: PHI learning Private Limited.
13. Nithyananda, K V. (2019). *Intellectual Property Rights: Protectionand Management*. India, IN: Cengage Learning India Private Limited.
14. Palekar, Subhas, *How to practice Natural Farming*, Pracheen (Vaidik) KrishiTantra Shodh,

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17. Raman, B.S., *Constitution of India*, New Delhi, 2002.
18. Reddy, B., Intellectual Property Rights and the Law, Gogia Law Agency.
19. Reddy, N.H., Santosh Ajmera, *Ethics, Integrity and Aptitude*, McGraw Hill, New Delhi.
20. Sharma, Brij Kishore, *Introduction to the Constitution of India*, New Delhi,
21. Schumacher, E.F., *Small is Beautiful: A Study of Economics as if People Mattered*, Blond & Briggs, Britain, 1973.
22. Singles, Shubham et. al., *Constitution of India and Professional Ethics*, Cengage Learning India Pvt. Ltd., Latest Edition, New Delhi, 2018.
23. Tripathy, A.N., *Human Values*, New Age International Publishers, New Delhi, 2003.
24. Wadehra, B.L., Law relating to Intellectual Property, Universal Law Publishing Co.

Relevant Websites, Movies and Documentaries:

25. *Value Education Websites*, http://uhv.ac.in, http://www.uptu.ac.in.
26. *Story of Stuff*, http://www.storyofstuff.com
27. Cell for IPR Promotion and Management: http://cipam.gov.in/.
28. World Intellectual Property Organization: https://www.wipo.int/about-ip/en/
29. Office of the Controller General of Patents, Designs & Trademarks: http://www.ipindia.nic.in/
30. Al Gore, *An Inconvenient Truth*, Paramount Classics, USA.
31. Charlie Chaplin, *Modern Times*, United Artists, USA.
32. *Modern Technology – The Untold Story*, IIT, Delhi.
33. A. Gandhi, *Right Here Right Now*, Cycle wala Productions.

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Session: 2025-26 (As per scheme 2024-25)			
Part A–Introduction			
Name of Programme	M. Sc. Physics		
Semester	3rd		
Name of the Course	Electrodynamics and Plasma Physics		
Course Code	M24-PHY-301		
Course Type	CC-9		
Level of the course	500-599		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	**CLO 301.1:** Have a sound knowledge of the basic concepts of electrostatics, and solve thePoisson's & Laplace's equations and the boundary value problems using the method of images. **CLO 301.2:** Understand the basic concepts of magnetostatics & apply them for solving the related problems, and recognize various 4-vectors & understand the Minkowski space. **CLO 301.3:** Describe the propagation of *em* waves through different media & rectangular waveguide, and learn the concept of retarded time & evaluate the Lienard-Wiechert potentials. **CLO 301.4:** Understand the basic concepts of Plasma Physics &the validity of plasma approximation, and realize the mechanism of plasma oscillations & have knowledge of plasma instabilities.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B-Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions: selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours

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I	**Electrostatics and Method of Images:** Electric Field, Gauss's Law, Differential Form of Gauss Law, Poisson's and Laplace's equations, Solution of Laplace's equation in various coordinates, Green's Theorem, Dirichlet and Neumann boundary conditions, Formal solution of boundary value problem with Green Function, Method of Images, Point charge near an infinite Grounded Conducting Plane, Point charge in the presence of Grounded Conducting Sphere, Point charge in the presence of Charged, Insulated Conducting sphere, Point charge near a Conducting Sphere held at Fixed Potential, Conducting sphere in a Uniform Electric Field.	15
II	**Magnetostatics, Maxwell Equations and Special Theory of Relativity:** Magnetostatics: Biot-Savart Law: Steady Currents, The magnetic field of a Steady Current, Ampere's Law, Comparison of Magnetostatics and Electrostatics, Maxwell's Displacement Current; Maxwell's Equations, Scalar and Vector potentials, Maxwell's equations in terms of scalar and vector potentials, Non-uniqueness of Electromagnetic potentials, Gauge Transformation, Lorentz gauge and Coulomb gauge, Minkowski Space and Four vectors, Mathematical Properties of the Space-Time of Special Relativity, Electromagnetic field strength tensors, Covariance of Maxwell's and Lorentz force equations.	15
III	**Electromagnetic Waves and Radiation by Moving Charges:** Electromagnetic Waves in Vacuum: The Wave Equation for E and B, Monochromatic Plane Waves, Energy and Momentum in Electromagnetic Waves. Electromagnetic Waves in Matter: Propagation in Linear Media, Reflection and Transmission at Normal Incidence, Reflection and Transmission at Oblique Incidence. Electromagnetic Waves in Conductors, Reflection at a Conducting Surface. Wave Guides, TE and TM Waves in a Rectangular Wave Guide, Retarded Time, Lienard-Wiechert Potentials for a point charge, Total power radiated by a point charge: Larmor's formula and its relativistic generalization.	15
IV	**Plasma Physics:** Occurrence of Plasmas in Nature, Quasi-neutrality of plasma, Debye Shielding, The Plasma Parameter, Criteria for Plasmas, Representation of Waves in Plasma, Group Velocity, Plasma Oscillations, Electron Plasma Waves, Sound Waves, Ion Waves, Validity of the Plasma Approximation, Comparison of Ion and Electron Waves, Electrostatic Electron Oscillations Perpendicular to B. Introduction to plasma Instabilities: Streaming instabilities, Rayleigh–Taylor instabilities, Universal instabilities, Kinetic instabilities. Velocity Distribution Function in Plasma, Derivation of the Fluid Equations as moments of the Boltzmann equation.	15
	Total Contact Hours	60

Suggested Evaluation Methods			
Internal Assessment: 30		**End Term Examination: 70**	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		

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• Mid-Term Exam:	15	

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Classical Electrodynamics by J.D. Jackson.
2. Introduction to Electrodynamics by D. J. Griffiths.
3. Introduction to Electrodynamics by A. Z. Capri and P. V. Panat.
4. Electrodynamics by S. P. Puri.
5. Introduction to Plasma Physics by F. F. Chen.
6. Introduction to Plasma Theory by D. R. Nicholson.

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Session: 2025-26 (As per scheme 2024-25)			
Part A - Introduction			
Name of Programme	M.Sc. Physics		
Semester	3rd		
Name of the Course	Statistical Mechanics		
Course Code	M24-PHY-302		
Course Type	CC-10		
Level of the course	500-599		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	CLO 302.1: Realize the fundamental connection between statistical mechanics and thermodynamics and learn the ensemble formulation of statistical mechanics. CLO 302.2: Formulate the quantum mechanical ensemble theory to derive the laws of quantum statistics for determining the equation of state for gases, and understand the origin of Bose-Einstein condensation. CLO 302.3: Grasp the basics of cluster expansion method for a classical real gas; Construct and solve the Ising model, along with the Landau theory of phase transition. CLO 302.4: Understand fluctuations, their spectral analysis and connection with spatial correlations, theoretical basis of Brownian motion on the basis of Enistein-Smoluchowski, and Langevin approaches.		
	Theory	Practical	Total
Credits	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B- Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Classical Statistical Mechanics:** Foundations of Statistical Mechanics: The	15

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	macroscopic and microscopic states, Postulate of equal a priori probability, Contact between statistics and thermodynamics; Entropy of mixing and the Gibbs paradox, Sackur-Tetrode equation. Ensemble theory: Concept of ensemble, Phase space, Density function, Ensemble average, Liouville"s theorem, Stationary ensemble: The microcanonical ensemble, The canonical and grand canonical ensembles, Application to the classical ideal gas; Canonical and grand canonical partition functions, Calculation of statistical quantities; Thermodynamics of a system of non-interacting classical harmonic oscillators using canonical ensemble and of classical ideal gas using grand canonical ensemble, Energy and density fluctuations.	
II	**Quantum Statistical Mechanics:** Quantum-mechanical ensemble theory: Density matrix, Equation of motion for density matrix, Quantum mechanical ensemble average; Statistics of indistinguishable particles, Fermi-Dirac and Bose-Einstein statistics, Fermi-Dirac and Bose-Einstein distribution functions using microcanonical and grand canonical ensembles (ideal gas only), Statistics of occupation numbers; Ideal Bose gas: Internal energy, Equation of state, Bose-Einstein Condensation and its critical conditions; BoseEinstein condensation in ultra-cold atomic gases: its detection and thermodynamic properties; Ideal Fermi gas: Internal energy, Equation of state, Completely degenerate Fermi gas.	15
III	**Non-Ideal Systems:** Cluster expansion method for a classical gas, Simple cluster integrals, Mayer-Ursell relations, Virial expansion of the equation of state, Van der Waal's equation, Validity of cluster expansion method; Phase transitions: Construction of Ising model, qualitative description of ferromagnetism, Lattice gas and Binary alloy, Solution of Ising model in the Bragg-William approximation, Exact solution of the one-dimensional Ising model; Critical exponents, Landau theory of phase transition, Scaling hypothesis. The role of correlation and fluctuation	15
IV	**Fluctuations:** Thermodynamic fluctuations and their probability distribution law, Spatial correlations in a fluid, Connection between density fluctuations and spatial correlations: Brownian motion, Enistein-Smoluchowski theory of Brownian Motion, Langevin theory of the Brownian motion (derivations of mean square displacement and mean square velocity of Brownian particle), Auto-correlation function and its properties, The fluctuation-dissipation theorem, Diffusion coefficient; the Fokker Planck equation; Spectral analysis of fluctuations: the Wiener-Khintchine theorem.	15
	Total Contact Hours	60

Suggested Evaluation Methods

Internal Assessment: 30		**End Term Examination: 70**	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

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1. Statistical Mechanics by R. K. Pathria (2nd Ed.)
2. Statistical Mechanics by R. K. Pathria and P. D. Beale (3rd edition)
3. Statistical and Thermal Physics by F. Reif
4. Statistical Mechanics by K. Huang
5. Statistical Mechanics by L. D. Landau and I. M. Lifshitz
6. Statistical Mechanics by R. Kubo

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Session: 2025-26 (As per scheme 2024-25)			
Part A–Introduction			
Name of Programme	M. Sc. Physics		
Semester	3rd		
Name of the Course	Condensed Matter Physics-I		
Course Code	M24-PHY-303		
CourseType	DEC-1^{S}		
Level of the course	500-599		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	**CLO 303.1:** Have an understanding of basic concepts related to semiconductors, and appreciate the concept of Fermi surface & its determination via De Hass-van Alphen effect, along with magneto-transport in a 2D channel. **CLO 303.2:** Learn about plasmons & electrostatic screening, and understand different physical quantities related to the optical response of solids & Raman Effect in crystals. **CLO 303.3:** Relate dielectric polarization with the macroscopic and local electric fields, along with frequency dependence of polarizability, and comprehend ferroelectricity & the Landau theory of phase transitions. **CLO 303.4:** Calculate magnetic susceptibility for atoms, insulators & conduction electrons, understand the origin of ferro/anti-magnetism, determine low-energy excitations (spin waves/magnons) for ferro- & antiferro-magnetic substances, and learn about ferromagnetic domains.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B- Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory

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question. All questions will carry equal marks.		
Unit	**Topics**	**Contact Hours**
I	**Semiconductor crystals, Fermi surfaces & metals, and Magnetotransport:** Semiconductor crystals: Band gap, Direct and indirect absorption processes; Equation of motion for an electron in an energy band, Concept and properties of holes, Effective mass and its physical interpretation, Effective masses in semiconductors, Examples of Silicon and Germanium; Intrinsic carrier concentration, Intrinsic mobility. Fermi surfaces and metals: Fermi surface and its construction for square lattice (free and nearly free electrons): Electron orbits, Hole orbits, Open orbits; Experimental determination of Fermi surface: Quantization of orbits in a magnetic field, De Hass-van Alphen effect, Extremal orbits. Magnetoresistance in a two-dimensional channel, Integral Quantized Hall Effect.	15
II	**Optical properties of solids:** Dielectric function of the free electron gas, Plasma optics, Dispersion relation for *em* waves, Transverse optical modes in a plasma, Transparency of metals in the ultraviolet, Longitudinal plasma oscillations, Plasmons and their measurement; Electrostatic screening, Screened Coulomb potential, Mott metal-insulator transition, Screening and phonons in metals; Optical reflectance, Kramers-Kronig relations, Electronic inter-band transitions; Excitons, Frenkel and Mott-Wannier excitons; Raman effect in crystals; Electron spectroscopy with X-rays.	15
III	**Dielectrics and Ferroelectrics:** Polarization, Macroscopic electric field, Dielectric susceptibility, Local electric field at an atom, Dielectric constant and polarizability, Clausius-Mossotti relation, Electronic polarizability, Classical theory of electronic polarizability; Structural phase transitions; Ferroelectric crystals and their classification; Displacive transitions; Landau theory of the phase transition, Second-order transition, First-order transition; Anti-ferroelectricity, Ferroelectric domains; Piezoelectricity, Ferroelasticity.	15
IV	**Magnetism:** Diamagnetism and paramagnetism: Magnetization density and susceptibility, Calculation of atomic susceptibilities, Larmor diamagnetism; Quantum theory of paramagnetism- Curie's law; Hund's rules; Paramagnetic susceptibility of conduction electrons. Ferromagnetism and anti-ferromagnetism: Ferromagnetic order, Mean field theory- Curie-Weiss law; Electrostatic origins of magnetic interactions, Magnetic properties of a two-electron system, Singlet-triplet (exchange) splitting in Heitler-London approximation, Exchange interaction; Spin Hamiltonian and the Heisenberg model; Spin waves and their dispersion; Quantization of spin waves, Magnons, Thermal excitation of magnons and Bloch $T^{3/2}$ law; Neutron magnetic scattering (principle); Ferromagnetic domains: Magnetization curve, Bloch wall, Origin of domains; Antiferromagnetic order and magnons.	15
	Total Contact Hours	60
Suggested Evaluation Methods		

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Internal Assessment: 30		End Term Examination: 70	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Introduction to Solid State Physics (7th edition) by Charles Kittel
2. Solid State Physics by Neil W. Ashcroft and N. David Mermin
3. Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth
4. Principles of the Theory of Solids (2nd edition) by J. M. Ziman
5. Condensed Matter Physics by Michael P. Marder
6. Advanced Solid State Physics by P. Phillips

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Session: 2025-26 (As per scheme 2024-25)			
Part A–Introduction			
Name of Programme	M. Sc. Physics		
Semester	3rd		
Name of the Course	Nuclear Physics-I		
Course Code	M24-PHY-304		
Course Type	DEC-1[s]		
Level of the course	500-599		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	**CLO 304.1:** Do Particle identification using solid state and gaseous detectors using the formalism of particle energy in two slices of the detectors. Learn about the concept, working and properties of various gas filled detectors. **CLO 304.2:** Describe the mechanisms adopted for processing a pulse through nuclear electronics, optimization of signal processing and techniques of coincidence for nuclear experiments. Understand the concept of pulse processing and data acquisition using different methods. **CLO 304.3:** Grasp the concept and working of different ion accelerators used in modern day nuclear/material research. Describe the mechanisms such as ion range, channelling and sputtering etc. associated with study of material properties. **CLO 304.4:** Understand about various type of fission reactors used in different branches of research and energy production. Understand the concept of fusion reactor and process of breeding in fission reactors.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B –Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The

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question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Particle Identification:** Basic principle of ΔE-E detector telescopes, short range charged particles ΔE-E telescope, methods of particle identification using semiconductor and gaseous detectors, ΔE-E time of flight spectroscopy; Event by event particle identification system for heavy ion induced reaction analysis; neutron-gamma discrimination; Modem Gas Detectors: basic principle and operation of split anode ionization chamber, position sensitive ionization chamber, position sensitive proportional counter & multi wire proportional counter.	15
II	**Nuclear Electronics:** Types of preamplifiers: basic idea of voltage sensitive and current sensitive pre-amplifiers, details of charge sensitive preamplifier and its applications; Amplifier Pulse Shaping Circuits: RC, Gaussian, delay-line, bipolar and zero cross-over timing circuits, pole zero cancellation and base line restorer; Coincidence Techniques: basic idea of coincidence circuit and its resolving time, basic principle of slow coincidence, slow fast coincidence and sum coincidence techniques, electronic considerations for pulse processing, device impedance, pulse attenuator, pulse splitter, linear and logic pulses, Single Channel Analyzer; Multi-Channel Analyzer; CAMAC Based Data Acquisition System.	15
III	**Ion Accelerators and Ion Beam Interaction in Solids:** Ion Accelerators: Ion sources- basic features of RF ion source, direct extraction negative ions source (Duoplasmatron) and source of negative ions by Cs sputtering (SNICS); Basic principle and working of Tandom accelerator and Pelletron accelerator and its applications; Ion Beam Interaction in Solids: Basic ion bombardment processes in solids- general phenomenon, ion penetration and stopping, ion range parameters, channelling, components of an ion implanter, energy deposition during radiation damage, sputtering process and ion beam mixing.	15
IV	**Nuclear Reactors:** Nuclear stability, fission, prompt and delayed neutrons, fissile and fertile materials- characteristics and production, classification of neutrons on the basis of their energy, four factor formula, control of reactors, reactors using natural uranium, principle of breeder reactors, fast breeder reactor & doubling time, calculation of critical size and mass of reactor; Basic principle of neutron detection; Basic concept of fusion reactors.	15
	Total Contact Hours	60

Suggested Evaluation Methods			
Internal Assessment: 30		**End Term Examination: 70**	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	

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• Seminar/presentation/assignment/quiz/class test etc.:	10	
• Mid-Term Exam:	15	

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Nuclear Radiation Detectors by S. S. Kapoor and V. S. Ramamurthy
2. Introduction to Experimental Nuclear Physics by R. M. Singru
3. Techniques for Nuclear and Particle Physics Experiments by W. R. Leo
4. Radiation Detection and Measurement by G. F. Knoll
5. The Physics of Nuclear Reactions by W. M. Gibson
6. VLSI Technology by S. M. Sze

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Session: 2025-26 (As per scheme 2024-25)			
Part A - Introduction			
Name of Programme	M.Sc. Physics		
Semester	3rd		
Name of the Course	Particle Physics-I		
Course Code	M24-PHY-305		
Course Type	DEC-I[5]		
Level of the course	500-599		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 305.1:** Realize the Fundamental constituents of matter, their origination, Understand qualitative and quantitative analysis of Resonance and Dalitz plots. **CLO 305.2:** Formulate Quantum mechanical scattering theory to understand origination of field particles, and understand three major interactions inexistence **CLO 305.3:** Understand Isospin formulation, Invariance and violation of various conservation laws and symmetries in these interactions. **CLO 305.4:** Formulate Parity conservation, violation and Charge conjugation invariance, Understand grand unification.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B-Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Wave Optical Description of Hadron Scattering:** Partial wave analysis for elastic scattering cross-section (non-identical and spin less particles), characteristic S and P wave scattering, reaction cross-section, optical theorem and its significance; elastic scattering cross-section (particles having spin) Resonanaces: Introduction to resonances, difference between resonances and unstable particles, $\Delta(1236)$ resonance, W and Z^0 Resonance, Briet- Wigner resonance formula and its significance, introduction to Dalitz plots with example of $K^+ \rightarrow 3\pi$	15

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	decay, discovery of charm, bottom and top quarks (qualitative description).	
II	**Isospin Formalism:** Concept of isospin, assignment of isospin to hadrons, Isospin Symmetry, isospin multiplets, generalized Pauli principle, assignment of isospin to deuteron in its ground state, isospin wavefuctions for nucleon-nucleon, pion-nucleon and pion-pion systems, isospin invariance in strong interactions through examples like, and, relative cross-section $\sigma_{pn\to d\pi^0}/\sigma_{pp\to d\pi^+} = 1/2$, and $\sigma_{pd\to 3He\pi^0}/\sigma_{pd\to 3H\pi^+} = 1/2$, relative cross sections for $\pi+p$ (elastic scattering), $\pi-p$ (elastic scattering) and $\pi-p$ (charge exchange) processes using isospin analysis, relation in Isospin Strangeness-Hypercharge.	15
III	**Conservation Laws:** Different Conservation laws and fundamental forces, The conservation of electric charge and stability of electron, the conservation of baryon number and stability of proton, Lepton number conservation, conservation and violation of isospin in different types of interactions, assignment of strangeness number to hadrons, strangeness conservation in strong and electromagnetic interactions and violation in weak interactions with suitable examples. The Gell-Mann-Nishijima formula, the baryon $3/2^+$ decuplet, $1/2^+$ octet and the meson 0- octet, 38 SU(3) classification of hadrons, qualitative idea of Grand Unification theory, prediction of proton decay.	16
IV	**Symmetry Principles:** Principals and fundamental of Symmetry, Charge conjugation invariance, suppression of $\pi^0 \to 3\gamma$ decay w. r. t. $\pi^0 \to 2\gamma$ decay, restrictions imposed by C invariance on the states of positronium annihilating in the modes e+ e- $\to 2\gamma$ 3γ, G-Parity, Γ-θ puzzle, parity conservation in strong and electromagnetic interactions and violation in weak decays, C and P operations on neutrino states, CPT theorem and its consequences.	14
	Total Contact hours	60

Suggested Evaluation Methods

Internal Assessment: 30		End Term Examination: 70	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Introduction to High Energy Physics (2nd, 3rd and 4th edition): D. H. Perkins.
2. Intermediate Energy Nuclear Physics: W. O. Lock and D. F. Measday.
3. Introduction to Particle Physics: M. P. Khanna.
4. Elementary Particle Physics: Yorikiyo Nagashia.
5. Symmetry Principles in Elementary Particle Physics: W. M. Gibson and B. R. Pollard.

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Session: 2025-26 (As per scheme 2024-25)			
Part A–Introduction			
Name of Programme	M. Sc. Physics		
Semester	3rd		
Name of the Course	Computational Physics-I		
Course Code	M24-PHY-306		
Course Type	DEC-2[5]		
Level of the course	500-599		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	**CLO 306.1:** Understand the working of Python programming language and be able to implement the learning into code writing. **CLO 306.2:** Understand various types of errors in numerical analysis and strategies to minimize loss of significance. Apply and analyze different methods for solving algebraic equations along with their convergence conditions. **CLO 306.3:** Learn techniques for interpolation and extrapolation using different formulas and interpolation methods. Learn and apply the principles of least squares curve fitting for linear, polynomial, exponential, and trigonometric models, including data fitting with cubic splines **CLO 306.4:** Gain proficiency in solving simultaneous linear algebraic equations using both direct and iterative methods, and understand error correction for ill-conditioned matrices. Learn to determine matrix eigenvalues and eigenvectors using polynomial and power methods.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B-Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question.

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All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Programming in Python :** Introduction to Python, Python interpreter, importing modules, data types, vectors, matrices, and multidimensional arrays, symbolic computing, plotting and visualization, equation solving, data input and output, looping conditions, defining functions, data fitting, arithmetic operations, Boolean arrays and conditional expressions, debugging.	15
II	**Errors and Solution of Algebraic Equations:** Errors: Round off error, Truncation error, Machine error, Random error, Propagation of errors. Loss of Significance: Significant Digits, Computer caused loss of significance, Avoiding loss of significance in subtraction. Solutions of algebraic equations: Bisection method, Iteration method, Method of false position, Newton-Raphson method, Generalized Newton Raphson method, Muller's method, Secant Method, Convergence condition of regula falsi method, Newton Raphson method, Muller's method, and secant method.	15
III	**Interpolation and Curve fitting :** Interpolation and Extrapolation: Finite differences, Forward differences, Backward differences, Central differences, Newton's formula for interpolation, Gauss central difference formula, Stirling's formula, Bessel's formula, Lagrange's interpolation formula, error of interpolation, Least square39curve fitting: The principle of least square fitting, Linear regression, Polynomial regression, Fitting exponential and trigonometric functions, Data fitting with cubic splines.	15
IV	**Systems of Linear Equations and Eigenvalue Problem :** Solutions of simultaneous linear algebraic equations: Gauss elimination method, Gauss Jordan elimination method, Doolittle method, Matrix inversion method, Ill-conditioned matrix and error correction, Jacobi Method, Gauss Seidel iterative method, Matrix eigenvalues and eigenvectors: Polynomial method, Power method.	15
	Total Contact Hours	60

Suggested Evaluation Methods

Internal Assessment: 30		End Term Examination: 70	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Numerical Python by Robert Johnsson.
2. Learn Python programming by Fabrizio Romano.
3. Introduction to computing and problem solving using Python by Balaguruswamy.
4. Introductory methods of Numerical Analysis by S. S. Sastry.
5. Computer Oriented Numerical Method by V. Rajamana.
6. Numerical Computational Methods by P B Patil and U. P. Verma.

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Session: 2025-26 (As per scheme 2024-25)			
Part A - Introduction			
Name of Programme	M.Sc.Physics		
Semester	3rd		
Name of the Course	Electronics-I		
Course Code	M24-PHY-307		
Course Type	DEC-2^{S}		
Level of the course	500-599		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 307.1:** Design and comprehend a host of OPAMP based linear analog electronic circuits. Design and understand various nonlinear analog electronic circuits with the help of OPAMPs. **CLO 307.2:** Gain a fair understanding of the operation and underlying circuitry of amplitude and frequency modulations. Understand the necessary circuitry of digital modulation techniques and Radars. **CLO 307.3:** Explain the principle of optical fibers, their various types & fabrication techniques. Comprehend connectors, splices and amplifiers in fiber optics communication **CLO 307.4:** Become familiar with the ideal MS contacts, their classification, surface effects and their important applications. Describe the basics of ideal and non-ideal MOS systems, MOS capacitance, MOS memories and charged-coupled devices.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B-Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	Linear analog systems: inverters, scale changers, phase shifters, adders, subtractors, voltage to current and current to voltage convertors, dc voltage follower, differential dc amplifier, bridge amplifier, ac coupled amplifier, instrumentation amplifier, integrator and differentiator, analog computer to solve linear differential equations with constant coefficients; non-linear analog systems: comparators, sample and hold	15

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	circuits, precision ac/dc convertors, log & antilog amplifiers, logarithmic multipliers and dividers, square, pulse and triangular waveform generators, regenerative comparator (Schmitt-trigger circuit).	
II	Basic operation and internal circuitry of PLL, active filters (Butter-Worth 1st and 2nd order), amplitude modulation, frequency spectrum and power in the AM wave, generation of AM waves, demodulation of AM waves, frequency modulation, block diagram of transmitter and super heterodyne receiver, digital communication, basic idea about delta modulation, PCM and PWM, block diagram of Radar, radar range equation and applications of Radars.	15
III	Optical fibers, basic principle, numerical aperture, V-parameter, types of optical fibers: single mode step index fiber, multimode step index fiber, multimode graded index fiber, material dispersion, signal degradation, fiber losses, fiber materials, fabrication methods for fiber cables: liquid-phase techniques, vapor-phase deposition techniques, fiber connectors and splices, applications of fiber cables, an introduction to semiconductor optical amplifiers.	15
IV	Metal semiconductor contacts, ideal MS contacts, Schottky barriers and ohmic contacts, surface effects on MS contacts, applications of MS contacts, the ideal MOS structure and its analysis, capacitance of MOS system, non-ideal MOS system: oxide and interface charges, origin of oxide charges, effect of bias voltage, MOS memories, and charge-coupled devices	15
	Total Contact hours	60

Suggested Evaluation Methods

Internal Assessment: 30		End Term Examination: 70	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Integrated electronics by J Millman & CC Halkias.
2. Micro Electronics by J Millman&AGrabel.
3. Electronic communications by D Roddy and J Coolen.
4. Electronic Communications: Modulation and Transmission by RJ Schoenbeck
5. OPAMPs and linear IC circuits by Ramakant A. Gayakwad
6. Electronic fundamentals and applications (5th ed.) by J D Ryder
7. Electronic Devices & Circuit Theory by Robert L Boylestad& Louis Nashelsky
8. Microelectronic Circuits: Theory and Applications (6th ed.) by Adel S Sedra and Kenneth C Smith

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Session: 2025-26 (As per scheme 2024-25)			
Part A–Introduction			
Name of Programme	M. Sc. Physics		
Semester	3rd		
Name of the Course	Material Science-I		
Course Code	M24-PHY-308		
Course Type	DEC-2^{S}		
Level of the course	500-599		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	**CLO 308.1:** Understand the basic concepts and properties of Materials and describe how and why defects (point, line and planar) in materials greatly affect engineering properties and limit their use in service **CLO 308.2:** Understand strengthening and grasp the importance of various strengthening mechanisms and describe various parameters involved in elastic deformation, plastic deformation, anelastic deformation etc. **CLO 308.3:** Grasp the concept of phase diagrams and be able to predict microstructures and understand transformation mechanisms (nucleation and growth, martensitic)and comprehend Iron-Carbon system and ceramics. .**CLO 308.4:** Elucidate the kinematics of elastic collisions and have in depth understanding energetic ion beam based techniques (given in the syllabus) for analysis of materials and perform computations of depth profiles and concentration analysis using these techniques, Choose the most appropriate technique for characterization.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

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Part B- Contents of the Course		
Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.		
Unit	**Topics**	**Contact Hours**
I	**Imperfections in Solids:** Point Defects: vacancy, substitutional, interstitial. Frenkel and Schottky defects, equilibrium concentration of Frenkel and Schottky defects; Line Defects: slip planes and slip directions, edge and screw dislocations, Burger's vector, cross-slip, glide and climb, jogs, dislocation energy, super & partial dislocations, dislocation multiplication, Frank Read sources; Planar Defects: grain boundaries and twin interfaces; Dislocation Theory – experimental observation of dislocation, dislocations in FCC, HCP and BCC lattice.	15
II	**Mechanical Properties:** Stress Strain Curve; Elastic Deformation: atomic mechanism of elastic deformation and anisotropy of Young's modulus, elastic deformation of an isotropic material; Anelastic and Viscous deformation; Plastic Deformation: Schmid's law, critically resolved shear stress; Strengthening Mechanisms: work hardening, recovery, recrystallization, strengthening from grain boundaries, low angle grain boundaries, Yield point, Strain aging, solid solution strengthening, two phase aggregates, strengthening from fine particles; Fracture: ideal fracture stress, brittle fracture-Griffith's theory, ductile fracture.	15
III	**Microstructure:** Solid Solutions and Intermediate Phases: phase rule, unitary & binary phase diagrams, Lever rule, Hume-Rothery rule; Free Energy and Equilibrium Phase Diagrams: complete solid miscibility, partial solid miscibility-eutectic, peritectic and eutectoid reactions, eutectaid mixture; Nucleation, Growth and Overall Transformation Kinetics; Martenstic Transformation; The Iron-Carbon System: various phases, phase diagram, phase transformations, microstructure and property changes in iron-carbon system; Ceramics: glass transition temperature, glassformers, commercial ceramics, mechanical properties, high temperature properties.	15
IV	**Materials Processing and Characterization:** Ion Implantation: introduction, ion implantation process, depth profile, radiation damage and annealing effects of trace-impurities, implantation induced alloying and structural phase transformation; Rutherford Backscattering Spectrometry (RBS): principle, kinematics of elastic collision, shape of the backscattering spectrum, depth profiles and concentration analysis, applications; Elastic Recoil Detection Analysis (ERDA): basic principle, kinematics, concentration analysis, depth profiling, depth resolution, applications; Secondary Ion Mass	15

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	Spectroscopy (SIMS): basic principle, working, yield of secondary ions and applications.			
			Total Contact Hours	60
Suggested Evaluation Methods				
Internal Assessment: 30			End Term Examination: 70	
➢ Theory		30	➢ Theory:	70
• Class Participation:		5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:		10		
• Mid-Term Exam:		15		
Part C-Learning Resources				

Recommended Books/e-resources/LMS:

1. Material Science by J. C. Anderson, K. D. Leaver, J. M. Alexander and R. D. Rawlings
2. Mechanical Metallurgy by G. E. Dieter
3. Ion Implantation by G. Dearnally
4. Fundamentals of Surface and Thin Film Analysis by L. C. Feldman and J. W. Mayer
5. Surface Analysis Methods in Material Science by D. J. O'Connor, B. A. Sexton and R. St. C. Smart (Eds), Springer Series in Surface Sciences 2023.

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Session: 2025-26 (As per scheme 2024-25)			
Part A – Introduction			
Name of Programme	M. Sc. Physics		
Semester	3rd		
Name of the Course	Physics Lab-V		
Course Code	M24-PHY-309		
Course Type	PC-5		
Level of the course	500-599		
Pre-requisite for the course (if any)	--		

NOTE: Unlike the M. Sc. First Year Laboratory, experiments in the Final Year Laboratories are based upon six different discipline elective courses (DECs). In this course, students shall complete at least six experiments from the DEC allotted. Besides continuous assessment of students through internal viva-voce examination of the experiments performed, there shall be end-semester laboratory examination wherein each student will be required to perform at least one experiment as per paper setting by a duly appointed panel of examiners. The evaluation will be made on the basis of performance of students in (i) experiment, (ii) report and analysis of the experiment and (iii) viva-voce examination.

DEC: Condensed Matter Physics-I

Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 309.1 Measure resistivity & band gap of a semiconductor by four-probe method and characterize it for carrier concentration & type using the Hall effect. CLO 309.2 Ascertain the magnetic nature of a material by measuring magnetic susceptibility. CLO 309.3 Record & analyze the XRD pattern of a crystal using X-ray diffractometer, and T_c of a high temperature superconductor. CLO 309.4 Simulate the dispersion of lattice vibrations using an electrical analogue of real lattice and compute dielectric function from reflectance data.		
Credits	Theory	Practical	Total
	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	

Part B- Contents of the Course	**Contact Hours**
Practicals 1. Measurement of resistivity of a semiconductor by four probe method at different temperatures and determination of band gap.	120

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2. Measurement of Hall coefficient of a given semiconductor: Identification of type of semiconductor and estimation of current carrier concentration. 3. Dispersion of lattice vibrations using electrical analogue of real lattice. 4. Magnetic susceptibility of hydrated copper sulfate. 5. Lattice parameter and Miller Indices using XRD. 6. Temperature dependence of a ceramic capacitor - Verification of Curie-Weiss law for the electrical susceptibility of a ferroelectric material. 7. Determination of specific heat of solids (metals and alloys). 8. Measurement of magnetic susceptibility by Quinck's method 9. High temperature superconductivity experiment. 10. Computation of dielectric function $\epsilon(\omega)$ from reflectance $R(\omega)$.	

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Introduction to Solid State Physics (7th edition) by Charles Kittel
2. Solid State Physics by Neil W. Ashcroft and N. David Mermin
3. Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth
4. Principles of the Theory of Solids (2nd edition) by J. M. Ziman
5. Condensed Matter Physics by Michael P. Marder
6. Advanced Solid State Physics by P. Phillips

DEC: Nuclear Physics-I

Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 309.1** Understand the working of different counters/detectors used in nuclear physics experiments. **CLO 309.2** Characterize the detectors response to different radiations under varying initial conditions. **CLO 309.3** Explore the applications of these detectors and associated electronics to find thickness of an unknown sample. **CLO 309.4** Determine the range of alpha particles in air, study the Compton scattering.		
Credits	Theory	Practical	Total
	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	

Part B- Contents of the Course

Practicals	Contact Hours
1. χ2-Statistics using G. M. Counter and establishing random nature of nuclear radiation 2. Resolving Time of G. M. Counter set-up. 3. To study the beta-gamma efficiency of G. M. Counter	120

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4. Study of Energy Resolution of NaI(Tl) detector and calibration of Gamma Spectrometer
5. To determine the wavelength of a given source using X-ray diffraction studies.
6. Estimating the thickness of a thin foil using alpha spectrometer.
7. Study of Bragg's curve and determining the range of alpha particles in air with Spark Counter
8. Compton Scattering Experiment.
9. Rutherford Back Scattering Experiment.
10. Study of particle/gamma coincidences.

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. 1. Introduction to Experimental Nuclear Physics by R. M. Singru
2. Techniques for Nuclear and Particle Physics Experiments by W. R. Leo
3. Radiation Detection and Measurement by G. F. Knoll

DEC: Particle Physics-I

Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 309.1** Learn and realize the concept of high energy (GeV) interaction, concept of internuclear cascading. **CLO 309.2** Understand the concept of slow and fast reaction involve in the high energy interaction. **CLO 309.3** Understand the fundamentals of production of field particles in bubble chamber. **CLO 309.4** Understand the mechanism of nuclear emulsion as a detector and target both. It helps to analyze the various interaction parameters qualitatively as well as quantitatively.		
Credits	Theory	Practical	Total
	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	

Part B- Contents of the Course

Practicals	Contact Hours
1. To determine the Primary Star Tracks using Inter-nuclear cascade model using nuclear emulsion and high energy particle. 2. To study the classification of the nuclear emulsion interaction and production of the field particle in 50 GeV π- Nuclear emulsion interaction. 3. To study the primary interaction and identify the shower tracks, grey and black tracks in nuclear emulsion interaction.	120

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4. To determine the Mean Multiplicity of shower, grey and black tracks in nuclear emulsion interaction. 5. To determine the heavy tracks and excitation energy for the Nuclear Interaction Star Tracks. 6. To determine the mean free path for relativistic nucleus-nucleus interactions. 7. To study p-p interaction and find the cross-section of a reaction using a bubble chamber.	

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Introduction to High Energy Physics (2nd and 4th edition): D. H. Perkins.
2. Particle Accelerator Physics, Vol I and II, H.J. Wiedman, (Springer Verlag), 1998.
3. Nuclear Tracks in Solids: Principles and Applications (1975): R. L. Fleischer, P. B. Price and R.M. Walker.
4. Nuclear Physics and Interaction of Particles with Matter: Academician D. V. Skobel'tsyn.
5. Particle Accelerators, M.S. Livingston and J.P. Blewel, (McGraw-Hill Book Press), 1962.

Suggested Evaluation Methods

Internal Assessment: 30		End Term Examination: 70	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/Demonstration/Viva-voce/Lab records etc.:	25		

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Session: 2025-26 (As per scheme 2024-25)			
Part A – Introduction			
Name of Programme	M. Sc. Physics		
Semester	3rd		
Name of the Course	Physics Lab-VI		
Course Code	M24-PHY-310		
Course Type	PC-6		
Level of the course	500-599		
Pre-requisite for the course (if any)	--		

NOTE: Unlike the M. Sc. First Year Laboratory, experiments in the Final Year Laboratories are based upon six different discipline elective courses (DECs). In this course, students shall complete at least six experiments from the DEC allotted. Besides continuous assessment of students through internal viva-voce examination of the experiments performed, there shall be end-semester laboratory examination wherein each student will be required to perform at least one experiment as per paper setting by a duly appointed panel of examiners. The evaluation will be made on the basis of performance of students in (i) experiment, (ii) report and analysis of the experiment and (iii) viva-voce examination.

DEC: Computational Physics-I

Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:			
	CLO 310.1 Develop Python programs to evaluate definite integrals by employing Simpson and Gauss quadrature methods.		
	CLO 310.2 Study interpolation/extrapolation using Lagrange's method, and least square curve fitting.		
	CLO 310.3 Construct Python program to solve second order differential equations using Runge-Kutta method and apply the program to find Eigenvalues and eigen functions of a linear harmonic oscillator.		
	CLO 310.4 Write program to solve set of Simultaneous Linear Algebraic equations by Gauss-Jordan elimination method, find eigen values and eigen vectors of square matrices, and Illustrate Kirchhoff's laws for simple electric circuits.		
Credits	Theory	Practical	Total
	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	

Part B- Contents of the Course	Contact Hours
Practicals	120

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1. Numerical Integration using (a) Simpson 1/3 and (b) Gauss quadrature methods for one and two-dimensional integrals.
   Application: Show that the function $f(x) = (n/\pi)(1/(1+n^2x^2))$ behaves like the Dirac delta function for large n.
2. Least Square fitting (Linear).
3. Solution of second-order differential equation using Runge-Kutta method. Application: Eigenvalues and eigenfunctions of a linear harmonic oscillator using Runge-Kutta method.
4. To find roots of an equation of degree 1, 2 and 3 by using Bisection method.
5. Solution of Simultaneous Linear Algebraic equations by Gauss-Jordan elimination method.
   Application: Illustration of Kirchhoff's laws for simple electric circuits.
6. Interpretation and Extrapolation by using Lagrangian method.
7. Finding eigenvalues and eigenvectors of square matrices.

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Numerical Python by Robert Johnsson.
2. Learn Python programming by Fabrizio Romano.
3. Introduction to computing and problem solving using Python by Balaguruswamy.
4. Introductory methods of numerical Analysis by S. S. Sastry.
5. Computer Oriented Numerical Method by V. Rajamana.
6. Numerical Computational Methods by P B Patil and U. P. Verma.

DEC: Electronics-I

Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 310.1** Design and measure h-parameters of an amplifier and pulse width of a mono-stable multivibrator circuit. **CLO 310.2** Measure the important parameters of an OPAMP. **CLO 310.3** Design different OPAMP based circuits for various practical applications. **CLO 310.4** Draw V-I characteristics of a solar cell and demonstrate modulation and demodulation circuits.		
Credits	Theory	Practical	Total
	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	

Part B- Contents of the Course

Practicals	Contact Hours
1. Determination of h-parameters of a bipolar transistor 2. Monostable Multivibrator: Measurement of pulse width for various time constants	120

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3. OPAMP-I: Measurement of various parameters
4. OPAMP-II: Applications as Adder, Subtracter, differentiator, integrator and voltage follower
5. Generation of square waves using OPAMP.
6. Generation of saw-tooth waves using OPAMP.
7. Generation of triangular waves using OPAMP.
8. To draw the V-I characteristics of a solar cell and to find fill-factor
9. To study the modulation and demodulation circuits.

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Integrated electronics by J Millman and CC Halkias.
2. Micro Electronics by J Millman and A Grabel.
3. Electronic communications by D Roddy and J Coolen.
4. Electronic Communications: Modulation and Transmission by RJ Schoenbeck
5. OPAMPs and linear IC circuits by Ramakant A. Gayakwad.
6. Electronic fundamentals and applications (5 th ed.) by J D Ryder.
7. Electronic Devices & Circuit Theory by Robert L Boylestad & Louis Nashelsky.
8. Microelectronic Circuits: Theory and Applications (6^{th} Ed.) by Adel S Sedra and Kenneth C Smith.

DEC: Material Science-I

Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 310.1:** Understand four probe method for determining band gap of materials and use it to compute band gap of semiconductor material by measuring the variation in potential drop with temperature. Comprehend the concept of Hall Effect and magnetoresistance. Measure Hall coefficient and establish the type of semiconductor and measure the magneto-resistance. **CLO 310.2:** Record and analyze the XRD pattern of a crystalline substance, using it compute Lattice parameters and Miller Indices. Understand dielectric materials and measure dielectric constant of given material. **CLO 310.3:** Learn about characteristics of a solar cell. Understanding of elastic behavior of materials and evaluating Young's modulus and elastic constant using Ultrasonic Interferometer. **CLO 310.4:** Understand XRF technique. Compute the elements and its composition using XRF

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	data		
Credits	Theory	Practical	Total
	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	

Part B- Contents of the Course

Practicals	Contact Hours
1. Band Gap of a given semiconductor material using Four-Probe method. 2. Study of Hall effect and estimation of Hall coefficient R, carrier density (n) and carrier mobility of Semiconductor material. 3. Lattice parameter and Miller Indices using XRD. 4. Dielectric constant of a given material. 5. Solar cell characteristics. 6. Study of the phenomenon of magneto-resistance. 7. Ultrasonic Interferometer – Young's modulus and elastic constant of solids 8. Determining the elements and its composition by XRF measurement of a sample.	120

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Material Science by J. C. Anderson, K. D. Leaver, J. M. Alexander and R. D. Rawlings
2. Mechanical Metallurgy by G. E. Dieter
3. Ion Implantation by G. Dearnally.
4. Fundamentals of Surface and Thin Film Analysis by L. C. Feldman and J. W. Mayer
5. Surface Analysis Methods in Material Science by D. J. O'Connor, B. A. Sexton and R. St. C. Smart (Eds), Springer Series in Surface Sciences 2023.

Suggested Evaluation Methods

Internal Assessment: 30		End Term Examination: 70	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/Demonstration/Viva-voce/Lab records etc.:	25		

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Session: 2025-26 (As per scheme 2024-25)			
Part A - Introduction			
Name of the Programme	M.Sc. Physics		
Semester	3RD		
Name of the Course	**Elements of Nano Science and Nano Technology**		
Course Code	M24-PHY-339		
Course Type	OEC		
Level of the course (As per Annexure-I	500-599		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 339.1**: Understand the basics of nanoscience. **CLO 339.2**: Describe the various techniques to fabricate nanostructure. **CLO 339.3**: Comprehend the principles and working of characterization tools for analyses of nanostructure. **CLO 339.4**: Grasp the concepts of various physical properties of nanostructures.		
Credits	Theory	Practical	Total
	2	0	2
Teaching Hours per week	2	0	2
Internal Assessment Marks	15	0	15
End Term Exam Marks	35	0	35
Max. Marks	50	0	50
Examination Time	3 hours		

Part B- Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Introduction to Nanomaterials:** Bottom up and Top Down approach, Classification of nanostructures: Zero dimension, one dimension and two dimensional nanostructures, Smart materials.	7
II	**Nanostructure fabrication by Physical Methods:** Physical Vapor deposition: evaporation, Molecular beam epitaxy, sputtering, comparison of evaporation and sputtering, Lithography: Photolithography, Electron Beam Lithography, X-ray lithography.	8
III	**Structural characterization:** X-ray diffraction, small angle X-ray scattering, Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy, Scanning Tunneling Microscopy, Spectroscopic Techniques: UV-Visible Spectroscopy, Photo-luminescence spectroscopy, Infra-red spectroscopy, Raman Spectroscopy	8
IV	**Physical properties of nanomaterials**: Melting points and lattice constants, Mechanical properties, Optical properties, Electrical conductivity, Super paramagnetism.	7

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		Total Contact Hours	30
Suggested Evaluation Methods			
Internal Assessment: 15		End Term Examination: 35	
➢ Theory	15	➢ Theory	35
• Class Participation:	4	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	4		
• Mid-Term Exam:	7		
Part C-Learning Resources			

Recommended Books/e-resources/LMS:

1. Introduction to Nanotechnology – Charles P. Poole Jr. and Frank J. Owens, Wiley India Pvt. Ltd., 2007.
2. Nanomaterials – Guozhong Cao, Imperial College Press, 2004.

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Session: 2025-26 (As per scheme 2024-25)			
Part A - Introduction			
Name of Programme	M. Sc. Physics		
Semester	4th		
Name of the Course	Atomic and Molecular Physics		
Course Code	M24-PHY-401		
Course Type	CC-11		
Level of the course	500-599		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 401.1:** Understanding of origination of atomic physics, analysis of spectral lines, change in behavior of atoms in external applied electric and magnetic field on atomic spectral lines, their selection rule. **CLO 401.2:** Construct and Analysis the rotational, vibrational and Raman spectra of molecules, learn the basic principle and instrumentation of IR and Raman spectrometer **CLO401.3:** Understand electronic energy spectroscopy, its rule, spectral range, application in understanding the characteristic feature molecular and electronic transition, the working and principle of UV-Visible and PL spectroscopy. **CLO 401.4:** Understand the theory and description of the nucleus interaction with external field, effect on their spectrum to understand the molecule, principle and instrumentation of NMR and ESR spectroscopy and formulation used in these spectroscopy.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		
Part B-Contents of the Course			

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory

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question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Atomic Physics:** Qualitative description of H-atom Spectrum, Physical interpretation of quantum numbers, Pauli principle and the building-up principle, Space Quantization: Stern-Gerlach experiment, spectrum of He-atom: its quantum mechanical description and Heisenberg resonance, LS and jj Coupling, Terms for equivalent & non-equivalent electron atom, Branching rule, Normal & anomalous Zeeman effect, Stark Effect, Paschen – Back effect; Intensities of spectral lines: General selection rule; Hyperfine structure of Spectra lines: Isotope effect and effect of Nuclear Spin.	15
II	**Molecular Physics:** Rotation of molecules: Classification of molecules, Interaction of radiation with rotating molecules, Rotational spectra of rigid diatomic molecules, Isotope effect in rotational spectra, Intensity of rotational lines, Non rigid rotator, Information derived from rotational spectra; Infrared spectroscopy: The vibrating diatomic molecule, The diatomic vibrating-rotator spectra of diatomic molecules, Infrared spectrophotometer; Raman Spectroscopy: Introduction, Pure rotational Raman spectra, Vibrational Raman Spectra, Nuclear Spin and intensity alternation in Raman spectra, Isotope effect, Raman Spectrometer.	15
III	**Electronic Spectra of diatomic molecules and Fluorescence spectroscopy:** Born Oppenheimer approximation, Vibrational coarse structure of electronic bands, Progression and sequences, Intensity of electronic bands-Frank Condon Principle, Dissociation and pre-dissociation, Dissociation energy; Rotational fine structure of electronic bands, The Fortratparabole, Electronic structure of diatomic molecules; UV-Visible Absorption spectroscopy, Lambert-Beer law, Absorption spectrometer. Fluorescence spectroscopy: Fluorescence and Phosphorescence, Kasha"s rule, Quantum Yield, Non-radiative transition, Jablonski Diagram, Spectrofluorometer, Time resolved fluorescence and determination of excited state lifetime.	15
IV	**Resonance Spectroscopy:** NMR: Basic principles, Classical and quantum mechanical description, Bloch equations, Spin-spin and spin-lattice relaxation times, Chemical shift, isotropy and anisotropy in chemical shift and coupling constant, NMR spectrometer, Experimental methods – Single coil and double coil methods, High resolution methods; ESR: Basic principles, ESR spectrometer, nuclear interaction and hyperfine structure, relaxation effects, g-factor, Characteristics, Free radical studies and biological applications.	15
	Total Contact Hours	60

Suggested Evaluation Methods			
Internal Assessment: 30		**End Term Examination: 70**	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		

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• Mid-Term Exam:	15	

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Concepts of Modern Physics by Arthur Beiser (McGraw-Hill Book Company, 1987).
2. Atomic spectra & atomic structure, Gerhard Hertzberg: Dover publication, New York.
3. Molecular structure & spectroscopy, G. Aruldhas: Prentice – Hall of India, New Delhi.
4. Fundamentals of molecular spectroscopy, Colin N. Banwell& Elaine M. McCash, Tata McGraw –Hill publishing company limited.
5. Introduction to Atomic spectra by H.E. White.
6. Spectra of diatomic molecules by Gerhard Herzberg.
7. Principles of fluorescence spectroscopy by Joseph R. Lakowicz.

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Session: 2025-26 (As per scheme 2024-25)			
Part A–Introduction			
Name of Programme	M. Sc. Physics		
Semester	4^{th}		
Name of the Course	Advanced Quantum Mechanics		
Course Code	M24-PHY-402		
Course Type	CC-12		
Level of the course	500-599		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	**CLO 402.1:**	Comprehend the basic laws of relativistic quantum mechanics; solve the Klein-Gordon &Dirac equations, and learn the concept of Dirac matrices &their properties for spin half relativistic particles.	
	CLO 402.2:	Acquire understanding of classical field & develop Lagrangian and Hamiltonian formulations for the same, and perform second quantization of a non relativistic field to find quantized energy & understand the matrix formulation of related operators.	
	CLO 402.3:	Implement second quantization of various relativistic fields to determine quantized energy, and establish scattering matrix using operators &represent various scattering processes using the Feynman Diagrams.	
	CLO 402.4:	Have sound understanding of semi-classical theory of radiation & check the validity of classical description, anddevelop theoretical understanding of emission & absorption of photons by atoms and find basic matrix elements for both processes	
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		
Part B- Contents of the Course			

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The

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compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Relativistic Wave Equations:** Klein-Gordan equation: Free particle, Charge and Current Densities, Electromagnetic potentials. Energy levels in a Coulomb Field (Hydrogen atom problem). Difficulties of Klein-Gordan equation. Dirac equation: Properties of the Dirac Matrices, Free particle solutions, Charge and Current Densities, Electromagnetic potentials. Dirac equation for a central field: Spin Angular Momentum, Approximate reduction; Spin-Orbit energy, Separation of the equation, The Hydrogen atom, Classification of energy levels, Negative energy States.	15
II	**Field Quantization:** Lagrangian Field Theory: Canonical Quantization Coordinates of the Field, The Classical Field Equations, Functional Derivative, Hamiltonian Formulation, Quantization of the Field, Field with more than one component, Complex Field, Non-relativistic field: Lagrangian and Hamiltonian Equations, Quantization for system of Bosons and Fermions, The N representation, Matrix representation of Creation, Annihilation and Number operators for Bosons and Fermions, Commutators and Anticommutators at unequal Times.	15
III	**Quantization of Relativistic Fields and Feynman Diagrams:** Relativistic Fields, Natural system of units, Quantization of Klein-Gordan field, Quantization of Dirac field, Quantization of Electromagnetic fields (in vacuum): Lagrangian and Hamiltonian Equations, Quantization Procedure, Quantized field energy. Interacting fields: Feynman Diagrams, Normal product, Dyson and Wick's chronological products, Contraction of field operators, Wick's theorem, Electromagnetic Coupling, The Scattering Matrix, Representation of various Scattering processes on Feynman diagrams up to second order.	15
IV	**Quantum theory of Radiation:** Classical radiation field: Transversality Condition, Fourier decomposition and radiation oscillators. Creation, Annihilation and Number operators: Quantization of radiation oscillators, Photon states. Quantized Radiation Field: Photons as quantum mechanical excitations of the radiation field, Fluctuations and the uncertainty relation, Validity of the classical description. Emission and Absorption of Photons by Atoms: Basic matrix elements for emission and absorption, Time dependent perturbation theory, Spontaneous emission in dipole approximation.	15
	Total Contact Hours	60

Suggested Evaluation Methods			
Internal Assessment: 30		**End Term Examination: 70**	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	

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• Seminar/presentation/assignment/quiz/class test etc.:	10	
• Mid-Term Exam:	15	
Part C-Learning Resources		

Recommended Books/e-resources/LMS:

1. Quantum Mechanics by L. I. Schiff (3^{rd} edition)
2. Quantum Mechanics by V. K. Thankappan.
3. Advanced Quantum Mechanics by J. J. Sakurai
4. Quantum Mechanics by A. P. Messiah
5. The principles of Quantum Mechanics by P. A. M. Dirac.
6. Relativistic Quantum Mechanics by Schwebe.

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Session: 2025-26 (As per scheme 2024-25)			
Part A–Introduction			
Name of Programme	M. Sc. Physics		
Semester	4th		
Name of the Course	Condensed Matter Physics-II		
Course Code	M24-PHY-403		
Course Type	DEC-3		
Level of the course	500-599		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	**CLO 403.1:**	Explicate response of electrons in a band to an external field & their scattering, calculate currents in bands, learn the Boltzmann approach for transport in metals, and understand different thermoelectric effects.	
	CLO 403.2:	Learn about nanostructures & principles of different imagining techniques, calculate the electronic structure of 1D, 0D nanostructures in effective mass approximation, and use it to explain electrical transport in these systems.	
	CLO 403.3:	Treat e-e interactions in Hartree and Hartree-Fock approximations &apply these to calculate electronic properties of simple metals, and learn to calculate the screened potential in the Thomas-Fermi and Lindhard approaches.	
	CLO 403.4:	Transform the many-particle Schrodinger equation to the second quantized form, and apply it to a degenerate homogenous electron gas for calculating the first-order ground-state energy.	
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B-Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory

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question.	All questions will carry equal marks.	
Unit	**Topics**	**Contact Hours**
I	**Electron Transport Phenomenon:** Difficulties with the Drude'smodel; Semiclassical model of electron dynamics: Bloch vs. Sommerfeld electrons, Wave packets of Bloch electrons, Semiclassical mechanics, Currents in bands and holes; Scattering of electrons in bands (elastic, inelastic and electron-electron scatterings): Non-equilibrium distribution function, Scattering probability and relaxation time, The Boltzmann equation, Relaxation time *ansatz* and linearized Boltzmann equation; Electrical and thermal conductivity of metals, Temperature dependence of resistivity and Matthiesen's rule; Thermoelectric effects, Thermopower, Seebeck effect, Peltier effect, Thomson effect, The Wiedemann-Franz law.	15
II	**Nanostructures and Electron Transport:** Nanostructures; Imaging techniques for nanostructures (only principle): Electron microscopy (TEM, SEM), Optical microscopy, Scanning tunneling microscopy, Atomic force microscopy; Electronic structure of 1D systems: 1D sub-bands, Van Hove singularities; 1D metals- Coulomb interactions and lattice couplings, Fermi vs. Luttinger liquid, Peierls instability; Electrical transport in 1D: Conductance quantization and the Landauer formula, Two barriers in series- Resonant tunneling, Incoherent addition and Ohm's law, Coherence-Localization: Electronic structure of 0D systems (Quantum dots): Quantized energy levels, Semiconductor nanocrystals, metallic dots, Optical spectra, Discrete charge states and charging energy; Electrical transport in 0D- Coulomb blockade, Coulomb oscillations.	15
III	**Beyond the independent electron approximation:** The basic Hamiltonian of a solid: Electronic and ionic/nuclei parts, The Born-Oppenheimer Approximation: The Hartree method, Connection with variational principle; Exchange: The Hartree-Fock approximation, Koopmans' theorem; Application of Hartree and Hartree-Fock methods to homogeneous electron gas- One-electron energy, Band width, DOS, Effective mass, Ground-state energy, Exchange energy; Concept of correlation energy; Screening in a free electron gas: The dielectric function, Thomas-Fermi theory of screening, Lindhard theory of screening, Calculation of Lindhard response function, Friedel oscillations, Frequency dependent Lindhard screening (no derivation).	15
IV	**Many-particle physics- Second quantization formulation:** Many-particle systems; The Schrodinger equation in first quantization, Expansion of wave function in the basis of single-particle wave functions, Symmetry of expansion coefficients, Normalized symmetric and anti-symmetric wave functions; Second quantization: Transformation of Schrodinger equation to occupation number representation for bosons and fermions, Many-particle Hilbert space, and creation and destruction operators, Second-quantized Hamiltonian; Fields, Hamiltonian and number-density operators in terms of field	15

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	operators; Application to degenerate homogeneous electron gas: First and second-quantized Hamiltonian operators, r_s parameter, Ground-state energy in first-order perturbation theory. Contact with the Hartree-Fock result, Exchange energy.	
	Total Contact Hours	60

Suggested Evaluation Methods			
Internal Assessment: 30		**End Term Examination: 70**	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Solid State Physics: An Introduction to Principles of Materials Science (4th Ed.) by H. Ibach and H. Luth
2. Introduction to Solid State Physics (8th Ed.) by Charles Kittel
3. Solid State Physics by Neil W. Ashcroft and N. David Mermin
4. Electronic Structure of Materials by Rajendra Prasad
5. The Wave Mechanics of Electrons in Metals by Stanley Raimes
6. Electronic Structure: Basic Theory and Practical Methods by Richard M. Martin
7. Quantum Theory of Many-particle Systems by A. L. Fetter and J. D. Walecka
8. Many-body Quantum Theory in Condensed Matter Physics by H. Bruus and K. Flensberg

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Session: 2025-26 (As per scheme 2024-25)			
Part A - Introduction			
Name of Programme	M.Sc.Physics		
Semester	4^{th}		
Name of the Course	**Nuclear Physics-II**		
Course Code	M24-PHY-404		
Course Type	DEC-3		
Level of the course	500-599		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 404.1** Learn basics of nuclear shell model to predict various nuclear properties using shell model. **CLO 404.2** Learn basics of nuclear collective model and to predict various nuclear properties using this model. **CLO 404.3** Acquire conceptual understanding of the general theory of nuclear scattering and reactions and analysis of the cross sections for compound and direct nuclear reactions. **CLO 404.4** Understand the key features of nuclear reactions involving weakly bound nuclei and heavy ion induced reactions.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B-Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Nuclear Models-I :** Liquid drop model, Outlines of Bohr and Wheeler theory of nuclear fission, Concept of magic numbers, The properties of magic nucleus, Nuclear Shell Model, Predictions of shell closure on the basis of harmonic oscillator potential, Need of introducing spin-orbit coupling to reproduce magic numbers. Extreme single particle model and its predictions regarding ground state spin parity, magnetic moment and electric quadrupole moments.	15
II	**Nuclear Models-II :** Nuclear surface deformations, General parameterization, Types of multipole deformations, Quadrupole	15

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	deformations, Symmetries in collective space. Surface vibrations, Vibrations of a classical liquid drop. The Harmonic quadrupole oscillator, The collective angular momentum operator. The collective quadrupole operator, Quadrupole vibrational spectrum, Rotating nuclei, The rigid rotor, The symmetric rotor, The asymmetric rotor.	
III	**Nuclear Reaction Theory** : Nuclear reactions and cross sections, Resonance : Breit-Wigner dispersion formula for $\ell= 0$, Breit-Wigner dispersion formula for all values of ℓ, The compound nucleus, Continuum theory of cross section , Statistical theory of nuclear reactions, Evaporation probability and cross sections for specific reactions, Kinematics of the stripping and pick-up reactions, Theory of stripping and pick-up reactions.	15
IV	**Heavy Ion Reactions and Exotic Nuclei:** Nuclear phenomena in heavy ion collisions: Coulomb excitation, Quasielastic reactions, fusion reactions, Deep inelastic reactions. Semi classical description of scattering: Role of classical deflection function, Special features: Interference, Rainbow scattering, Glory effect, Spiral scattering, Elastic scattering of alpha particles by atomic nuclei. Exotic nuclei: Production of rare isotopes, Breakup mechanisms of weakly bound nuclei, Halo and Borromean nuclei. Fusion mechanisms of weakly bound nuclei, Single channel description of fusion, Hill-Wheeler formula, Wong formula, barrier distribution, threshold anomaly.	15
	Total Contact hours	60

Suggested Evaluation Methods

Internal Assessment: 30		End Term Examination: 70	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. R. R. Roy and B. P. Nigam, "Nuclear Physics: Theory and Experiment", Wiley Eastern Limited, 1993.
2. M. K. Pal, "Theory of Nuclear Structure", Affiliated East-West Press, New Delhi.
3. W. Greiner and J. A. Maruhn, "Nuclear Models", Springer, 1996
4. R. A. Broglia and A. Winther, "Heavy Ion Reactions (Lecture Notes)", Benjamin/Cummings Publishing Company, Inc., 1981
5. Ford and Wheeler, Annals of Physics, Vol. 7 (1959) 259.
6. C. A. Bertulani, M. Hussein and G Muenzenberg, "Physics of Radioactive Beams", Nova Science, NY, 2002.
7. L. F. Canto et al., Physics Reports, Vol. 424 (2006) 1.

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Session: 2025-26 (As per scheme 2024-25)

Part A - Introduction			
Name of Programme	M.Sc. Physics		
Semester	4^{th}		
Name of the Course	Particle Physics-II		
Course Code	M24-PHY-405		
Course Type	DEC-3		
Level of the course	500-599		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 405.1:** Realize the Weak interaction, Leptons fundamentals, and their decay; understand the concept of Helicity, Higgs field and Higgs Bosons. **CLO 405.2:** Understand of 4-vector momentum, and its importance in calculations at relativistic energies involved in various reactions and decay. **CLO 405.3:** Understand the interaction of charge particles with matter, able to calculate and understand the dynamics of high energy particles, Energy loss and Straggling mechanism. **CLO 405.4:** Understand radiations mechanism at relativistic velocities, Grasp details of particle accelerators for the creation of high energy particles will be provided.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B- Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Weak Interactions:** Fundamentals and Classification of weak interactions, Decay process, Leptonic, semi-leptonic and non-leptonic decays; Concept of Helicity. Helicity conservation, Helicity assigned to neutrino and antineutrino. Helicity assigned to other particles involved in these decays, helicity of neutrino and anti-neutrino, C-P invariance and violation in K0 decay, $\pi \rightarrow \mu$ and $\pi \rightarrow e$ branching ratios and its outcome, weak decay of strange particles- selection rules for non-	15

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	leptonic and semi-leptonic decays, suppression of $\Delta S=1$ transitions in comparison to $\Delta S=0$ transitions- Cabibbo theory, Introduction to Higgs boson.	
II	**Relativistic Kinematics**: Kinematics in relativistic regime, Lorentz transformation, Concept of 4-vector notation and its importance, Calculation of center of mass energy for two particles colliding in lab frame, advantage of colliding beam experiments in comparison to fixed target experiments, derivation of expression to calculate threshold energy of the projectile hitting a stationary target resulting in production of additional particles (examples like $pp \rightarrow pppp$, $pp\pi$, $ppk^{+}k^{-}$, $ppk^{0}k^{0}$, $\Sigma^{+}k^{0}p$, etc.), calculation of energies of the decay products in the rest frame of the decaying particle from the two body decay like $A \rightarrow B + C$.	15
III	**Interaction of energetic particles with Matter**: Passage of Charged Particles Through Matter, Ionization loss of charged particles, derivation of stopping power equation for electronic loss based on impact parameter approach, Bethe-Bloch formula (no derivation), concept of effective charge, Shell and Density effect corrections, scaling law and its importance, nuclear energy Loss, radiation loss of electrons-Bremsstrahlung process, emission of Cerenkov radiations at relativistic velocities, stopping power in compounds- Bragg's additivity rule, concept of energy loss, straggling, collisional and charge exchange straggling.	15
IV	**Particle Detectors and Accelerators**: Nuclear emulsion detector-principle and mechanism for charged particle detection, nuclear emulsion as a 4π detector, advantage of nuclear emulsion in relativistic hadron-nucleus interactions (multiplicity, momentum, energy distributions of produced particles); Solid state nuclear track detectors- principle and mechanism of detection of nuclear charged particles, Ion-explosion spike model and its predictions, restricted energy loss model for organic detectors; Basic principle of working of cloud chamber, bubble chamber, Cerenkov counter; Calorimeters- formation of electromagnetic and hadron showers; Principle of neutrino detection Accelerators: Principle and important features of Linear accelerator (LINACs), cyclic accelerator (synchrotrons): electron synchrotron, colliding beam machine, Introduction to Large Hadron collider.	15
	Total Contact hours	60

Suggested Evaluation Methods

Internal Assessment: 30		**End Term Examination: 70**	
➢ **Theory**	30	➢ **Theory:**	**70**
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Introduction to High Energy Physics (2nd and 4th edition): D. H. Perkins.
2. Solid State Nuclear Tracks Detection, 'Principle Methods and Applications: S. A. Durrani

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and R. K. Bull.
3. Nuclear Tracks in Solids: Principles and Applications (1975): R. L. Fleischer, P. B. Price and R.M. Walker.
4. Introduction to Particle Physics: M. P. Khanna.
5. Elementary Particle Physics: Yorikiyo Nagashima.
6. Symmetry Principles in Elementary Particle Physics: W. M. Gibson and B. R. Pollard.
7. Particle Physics: Anwar Kamal
8. Nuclear Physics and Interaction of Particles with Matter: Academician D. V. Skobel'tsyn

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Part A–Introduction

Name of Programme	M. Sc. Physics
Semester	4th
Name of the Course	Computational Physics-II
Course Code	M24-PHY-406
Course Type	DEC-4
Level of the course	500-599
Pre-requisite for the course (if any)	--
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	**CLO 406.1:** Apply various numerical methods for finding differentiation and integration appearing in physical problems and find numerically double integration and integration of singular integrals. **CLO 406.2:** Solve ordinary and partial differential equations using numerical methods and Understand hydrogen atom problem more conspicuously by solving the concerned Schrodinger equation numerically. **CLO 406.3:** Understand the concept of random numbers and generate sequence of random numbers by employing various methods and apply random number sequences in the simulation of random processes like nuclear radioactivity and chaotic systems. **CLO 406.1:** Learn the fundamental concepts involved in simulation of simple physical phenomena and develop algorithms to simulate physical processes like LR, LC, LCR circuits, Rutherford scattering etc.

	Theory	Practical	Total
Credits	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B-Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

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Unit	Topics	Contact Hours
I	**Differentiation and Integration:** Differentiation: Taylor series method, Numerical differentiation using Newton's forward difference formula, Backward difference formula, Stirling's formula, Cubic splines method, Drawbacks of numerical differentiation, Integration: Trapezoidal rule, Trapezoidal rule from Lagrange linear interpolation, Simpson's 1/3 rule, Simpson's 3/8th rule, error in integration (Simpson and Trapezoidal), Gaussian Quadrature, Legendre–Gauss Quadrature, Numerical double integration, Numerical integration of singular integrals, Debye model.	15
II	**Solution of Differential Equations:** Numerical solution of ordinary differential equations: Single step method, multi-step method, Taylor's series method, Euler's method, Modified Euler's method, Fourth-order Runge Kutta method, Cubic splines method; Second order differential equations: Initial and boundary value problems, Numeric solution of radial Schrodinger equation for Hydrogen atom using Fourth-order-Runge-Kutta method (when eigenvalue is given). Numerical Solutions of Partial Differential Equations using Finite Difference Method, Stability of numerical methods.	15
III	**Random Numbers and Chaos:** Random numbers: Random sequences, Random number generators, Seeding, Mid-square methods, Multiplicative congruential method, Mixed multiplicative congruential methods, Modeling radioactive decay, Hit and miss Monte-Carlo methods, Monte-Carlo calculation of π, Monte-Carlo evaluation of integration, Evaluation of multidimensional integrals; Chaotic dynamics: Some definitions, The simple pendulum, Potential energy of a dynamical system, Portraits in phase space: Undamped motion, Damped motion, Driven and damped oscillator. Elementary probability theory, Binomial, Poisson and normal distributions, Central limit theorem.	15
IV	**Simulation of selected physics problems:** Algorithms and programs to simulate interference and diffraction of light, Simulation of charging and discharging of a capacitor, current in LR and LCR circuits, Computer models of LR and LCR circuits driven by sine and square functions, Computer model of Rutherford scattering experiment, Simulation of electron orbit in H_2 ion.	15
	Total Contact Hours	60

Suggested Evaluation Methods			
Internal Assessment: 30		**End Term Examination: 70**	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

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1. P. B. Patil and U. P. Verma, Numerical Computational Methods, Narosa Publishing House
2. M. L. De Jong, Introduction to Computation Physics, Addison-Wesley publishing company.
3. R. C. Verma, P K Ahluwalia and K C Sharma, Computational Physics an Introduction, New Age International Publisher.
4. S. S. Sastry Introductory methods of numerical Analysis, Prentice Hall of India Pvt. Ltd.
5. C. BalachandraRao and C K Santha, Numerical Methods, University Press
6. K. E. Atkinson, An introduction to numerical analysis, John Wiley and Sons.

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Session: 2025-26 (As per scheme 2024-25)			
Part A - Introduction			
Name of Programme	M.Sc. Physics		
Semester	4th		
Name of the Course	Electronics-II		
Course Code	M24-PHY-407		
Course Type	DEC-4		
Level of the course	500-599		
Pre-requisite for the course (if any)	--		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	**CLO 407.1:** Understand the fabrication processes for devices and ICs like crystal growth, Oxidation, pattern transfer, diffusion, etching, ion-implantation and epitaxial growth. Gain knowledge of inter-connections, packaging and the processing of compound semiconductors. **CLO 407.2:** Obtain a fair understanding of the steps involved in the fabrication of electronic devices like BJT, MOSFET, FET, CMOS, Schottky diodes, IC diodes, capacitors and resistances. Know the need of Clean rooms & their classifications. **CLO 407.3:** Gain a fair understanding of the operation and applications of decoders, demultiplexers, multiplexers, encoders and flip-flops. Comprehend the operation and applications of RAMs, ROMs, 555 IC timer, D/A and A/D converters. **CLO 407.4:** Describe the operation and important applications of half and full adders, and shift- resistors. Explain operation and important applications of asynchronous and synchronous counters.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		
Part B-Contents of the Course			

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The

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question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	Silicon planar process, crystal growth, wafer production, thermal oxidation, high pressure oxidation, concentration enhanced oxidation, chlorine oxidation, lithography & pattern transfer, etching process, factors affecting the etching process, HF-HNO_3 system, dopant addition, ion implantation, diffusion, diffusion in concentration gradient, Fick's Laws, diffusivity variation, Segregation, chemical vapor deposition techniques.	15
II	Epitaxial and non-epitaxial films, inter connection and packaging, compound semiconductors processing, monolithic IC technology, BJT fabrication, PNP transistor, multi-emitter Schottky transistor, superbeta transistor fabrication, fabrication of FET/NMOS enhancement as well as depletion transistors, fabrication of CMOS devices, monolithic diodes, IC resistors and capacitors, Clean rooms & their classifications.	15
III	QM method for the simplification of Boolean functions (upto 4 variables), Decoder, Demultiplexer, Multiplexer and Encoder. Flip-flops: RS, JK, master-slave-JK, D-Type and T-type flip-flops, ROM and its applications in look-up tables, sequence generator, seven-segment display, character generator and combinational logic, programmable ROM (PROM) and erasable PROM (EPROM), random access memory (RAM), D/A Converters: weighted resister, R-2R ladder, A/D converter; the 555 IC timer as mono and astable multivibrators.	15
IV	Half adders, full adders and their use as substractors, shift resistor, applications of shift registers as digital delay line, serial-to-parallel converter, parallel-to-serial converter, ring counter, twisted ring counter, sequence generator; ripple (asynchronous) counters: up-down counter, divided-by-N counter, synchronous counter design, up-down synchronous counter with parallel carry, Asynchronous versus synchronous sequential circuits, Applications of counters.	15
	Total Contact hours	60

Suggested Evaluation Methods

Internal Assessment: 30		End Term Examination: 70	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Integrated Electronics by J Millman and CC Halkias
2. Theory and Application of Micro Electronics by SK Gandhi.
3. Micro Electronics by J Millman & A Grabel.
4. Digital Computer Electronics by AP Malvino.
5. Device Electronics for Integrated Circuits by RS Muller and TI Kamins.

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6. VLSI Fabrication Principal and Practice by SK Gandhi.
7. Semiconductor Devices Physics and Technology by SM Sze.
8. Modern Digital Electronics by RP Jain.
9. Introduction to semiconductor Materials and Devices by MS Tyagi.

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Session: 2025-26 (As per scheme 2024-25)			
PartA–Introduction			
Name of Programme	M. Sc. Physics ,		
Semester	4^{th}		
Name of the Course	Material Science-II		
Course Code	M24-PHY-408		
CourseType	DEC-4		
Level of the course	500-599		
Pre-requisite for the course (ifany)	---		
CourseLearningOutcomes (CLOs) After completing this course, the learner will to:	**CLO 408.1:**	Comprehend various tests (Tension test, hardness tests, Impact test, fatigue test, creep test) used for measuring the mechanical properties of materials and Realize the difference between strength and hardness of materials. Compute various strength and ductility measures from engineering stress-strain curve and true stress-strain curves.	
	CLO 408.2:	Understand magnetic processes, Diamagnetism, Paramagnetism, density of states curves for a metal; and Grasp the concepts of Ferromagnetism, exchange interactions, domain structure; Antiferromagnetism, Ferrimagnetism and Ferrites	
	CLO 408.3:	Elucidate the physics describing dielectrics and ferroelectric materials, with focus on the functionality and Describe the optical properties of insulators	
	CLO 408.4:	Understanding of the surface and concepts of salvage depth and Grasp the concept, working and applications of different electron and photon based surface analysis techniques.	
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		
PartB-Contentsofthe Course			

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The

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compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unitand the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Material Testing:** The Tension Test: engineering stress-strain curve, true stress-strain curve, instability in tension, Considere's construction, ductility measurement, effect of strain rate on flow properties, strain rate sensitivity; notch tensile test; The Hardness Test: Brinell hardness, Meyer hardness, Vicker's hardness number and test, Rockwell hardness test, Knoop hardness number and test; The Impact Test: brittle fracture problem, notched bar impact tests-Carpy and Izod Impact tests; The Fatigue Test: fatigue failures, stress cycles, the S-N curve, fatigue limit; The Creep Test: creep curve, primary, secondary and tertiary creep, effect of temperature and stress on the creep curve.	15
II	**Magnetic Materials:**Magnetic Processes: Larmor frequency; Diamagnetism, magnetic susceptibility, Langevin's diamagnetism equation; Paramagnetism, Curie constant, density of states curves for a metal; Ferromagnetism, Curie temperature, Curie-Weiss law, exchange interactions, domain structure; Antiferromagnetism and magnetic susceptibility of an antiferromagnetic material; Ferrimagnetism and Ferrites; Paramagnetic, ferromagnetic and cyclotron-resonance.	15
III	**Dielectric, Optical and Ferroelectric Materials:** Introduction, Energy bands, dielectric constant, complex permittivity, dielectric loss factor, polarization, mechanism of polarization, classification of dielectrics-frequency dependence of dielectric constant; Optical Phenomena in Insulators Colour of crystals - Excitons - weakly bound and tightly bound excitons. Colour centers – F-centers and other electronic centers in alkali halides. Ferroelectrics: General characteristics - piezoelectric, pyroelectric and ferroelectric materials. Classification of ferroelectrics and representative materials. Ferroelectric domains. Polarization catastrophe, Landau theory of first and second-order phase transitions, antiferroelectric materials .	15
IV	**Solid Surfaces and Analysis:** Surface and its importance, selvedge depths of surface; Methods of Surface Analysis: Auger Electron spectroscopy (AES)- basic principle, methodology, composition analysis and depth profiling; X-ray photoelectron spectroscopy (XPS) or ESCA: principle, methodology and quantitative analysis; Glancing angle X-ray Diffraction (GXRD), basic concept, methodology and structural analysis; Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM): Principle, methodology and Applications in surface analysis; Atomic Force Microscopy (AFM): Basic principle, Methodology, applications in structural analysis.	15
	Total Contact Hours	60
	SuggestedEvaluationMethods	
	InternalAssessment: 30	**End Term Examination: 70**

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➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

PartC-Learning Resources

Recommended Books/e-resources/LMS:

1. Material Science, J.C. Anderson, K.D. Leaver, J. M. Alexander and R. D. Rawlings
2. Mechanical Metallurgy, G.E. Dieter.
3. Electronic Processes in Materials, L. V. Azaroff and J. J. Brophy
4. Fundamentals of Surface and Thin Film Analysis, L.C. Feldman and J. W. Mayer
5. Surface Analysis Methods in Material Science, D. J. O'Connor, B. A. Sexton and R. St. CSmart (Eds), Springer Series in Surface Sciences 23
6. Solid State Physics – A J Dekker (McMillan, 1971)
7. Materials Science and Engineering by William D. Callister

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Session: 2025-26 (As per scheme 2024-25)	
PartA – Introduction	
Name of Programme	M. Sc. Physics
Semester	4th
Name of the Course	Physics Lab-VII
Course Code	M24-PHY-409
CourseType	PC-7
Level of the course	500-599
Pre-requisite for the course (ifany)	--

NOTE: Unlike the M. Sc. First Year Laboratory, experiments in the Final Year Laboratoriesare based upon six different discipline elective courses (DECs). In this course, students shall complete at least six experiments from the DEC allotted. Besides continuous assessment of students through internal viva-voce examination of the experiments performed, there shall be end-semester laboratory examination wherein each student will be required to perform at least one experiment as per paper setting by a duly appointed panel of examiners. The evaluation will be made on the basis of performance of students in (i) experiment, (ii) report and analysis of the experiment and (iii) viva-voce examination.

DEC: Condensed Matter Physics-II

CourseLearningOutcomes (CLOs) After completing this course, the learner will be able to:	**CLO 409.1**Explore variation of Hall coefficient with temperature, and measure the magneto-resistance &T_c of ferrites. **CLO 409.2**Measure characteristics of a thermo-luminescent material and to determine the Landeg-factor from the ESR experiment. **CLO 409.3**Hands on experience of electron diffraction phenomenon, Zeeman effect, and band gap measurement using UV-VIS spectroscopy. **CLO 409.4**Compute the electronic structure, dielectric function, etc.		
Credits	Theory	Practical	Total
	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	

PartB-Contentsofthe Course	**Contact Hours**
Practicals	120

1. Temperature dependence of Hall coefficient.
2. Transition temperature of ferrites.
3. Study of the phenomenon of magneto-resistance.
4. Thermo-luminescence studies.
5. Determination of Lande's factor of DPPH using Electron Spin Resonance (ESR) spectrometer.

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6. Dielectric constant of benzene and dipole moment of acetone. 7. Electron diffraction experiment: Determining the wavelength of electrons for different accelerator voltages by applying the Bragg'slaw. 8. Zeeman Effect experiment. 9. Determination of band gap using UV-VIS spectroscopy. 10. Computation of electronic structure of a material. 11. Computation of dielectric function of a metallic solid.	

PartC-Learning Resources

Recommended Books/e-resources/LMS:

1. Introduction to Solid State Physics (7th edition) by Charles Kittel
2. Solid State Physics by Neil W. Ashcroft and N. David Mermin
3. Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth
4. Principles of the Theory of Solids (2nd edition) by J. M. Ziman
5. Condensed Matter Physics by Michael P. Marder
6. Advanced Solid State Physics by P. Phillips

DEC: Nuclear Physics-II

CourseLearningOutcomes (CLO) After completing this course, the learner will be able to:	**CLO 409.1:**Learn the concept of simulation and simulate the response of different detectors. **CLO 409.2:** Calibrating a gamma detector and identifying different gamma emitters from an unknown source. **CLO 409.3:** Calibrate an alpha spectrometer and find the energy resolution of the spectrometer. **CLO 409.4:** Find efficiency of a given detector and study gamma attenuation in an absorber.		
Credits	Theory	Practical	Total
	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	

PartB-Contentsofthe Course

Practicals	Contact Hours
1. To determine the thickness of Al Sheet using G. M. Counter. 2. Mass attenuation coefficient of Gamma Rays in lead with G. M. Counter 3. Estimating the Efficiency of NaI (Tl) Detector. 4. Simulating the response of Geiger Muller counter to radiations. 5. Simulating the response of a scintillator to radioactive sources after incorporating all three gamma interactions. 6. Simulating the response of ΔE-E detector telescope and calculation of energy loss of incident particles. 7. Study of alpha spectrum for shape properties and energy calibration of an alpha spectrometer. 8. Identification of different gamma emitters from an unknown sample.	120

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9. Resolving Time of a Fast Coincidence Circuit.	

PartC-Learning Resources

Recommended Books/e-resources/LMS:

7. 1. Introduction to Experimental Nuclear Physics by R. M. Singru
8. Techniques for Nuclear and Particle Physics Experiments by W. R. Leo
9. Radiation Detection and Measurement by G. F. Knoll

DEC: Particle Physics-II

CourseLearningOutcomes (CLO) After completing this course, the learner will be able to:	**CLO 409.1:** Understand the relativistic kinematics in high energy interaction. **CLO 409.2:** Learn the mechanism of energy transfer of incident ion in material medium. **CLO 409.3:** Understand the aspects in radiation exposure, etching mechanism and statistics involve in nuclear charge particle interaction with material medium using SSNTD. **CLO 409.4:** Learn the aspects of bubble chamber and interaction of incoming high energy particle radiation.		
Credits	Theory	Practical	Total
	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	

PartB-Contentsofthe Course

Practicals	Contact Hours
1. To determine the Angular distribution of shower particles in nuclear emulsion interaction. 2. To determine the Momentum distribution of shower particles in nuclear emulsion interaction. 3. To determine the In-elasticity of an interaction for shower particles in nuclear emulsion interaction. 4. To study the Exposure and etching of polymeric sample for the preparation of Solid State Nuclear Track Detector (SSNTD). 5. To study the Nuclear Statistics (To study Poisson and Gaussian distributions) using Solid State Nuclear Track Detector. 6. To study n-p interaction and find the cross-section using a bubble chamber. 7. To study k-d interaction and find its multiplicity and moments using a bubble chamber.	120

PartC-Learning Resources

Recommended Books/e-resources/LMS:

1.Introduction to High Energy Physics (2nd and 4thEds.): D. H. Perkins.

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2. Particle Accelerator Physics, Vol. I and II, H.J. Wiedman, (Springer Verlag), 1998.
3. Nuclear Tracks in Solids: Principles and Applications (1975): R. L. Fleischer, P. B. Price and R.M. Walker.
4. Nuclear Physics and Interaction of Particles with Matter: Academician D. V. Skobel'tsyn.
5.Particle Accelerators, M.S. Livingston and J.P. Blewel, (McGraw-Hill Book Press), 1962.

SuggestedEvaluationMethods			
InternalAssessment: 30		**End Term Examination: 70**	
➢ **Theory**	**30**	➢ **Theory:**	70
• Class Participation:	5	Written Examination	
• Seminar/Demonstration/Viva-voce/Lab records etc.:	25		

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PartA – Introduction			
Name of Programme	M. Sc. Physics		
Semester	4^{th}		
Name of the Course	Physics Lab-VIII		
Course Code	M24-PHY-410		
CourseType	PC-8		
Level of the course	500-599		
Pre-requisite for the course (ifany)	--		

NOTE: Unlike the M. Sc. First Year Laboratory, experiments in the Final Year Laboratoriesare based upon six different discipline elective courses (DECs). In this course, students shall complete at least six experiments from the DEC allotted. Besides continuous assessment of students through internal viva-voce examination of the experiments performed, there shall be end-semester laboratory examination wherein each student will be required to perform at least one experiment as per paper setting by a duly appointed panel of examiners. The evaluation will be made on the basis of performance of students in (i) experiment, (ii) report and analysis of the experiment and (iii) viva-voce examination.

DEC: Computational Physics-II

CourseLearningOutcomes (CLOs) After completing this course, the learner will be able to:	**CLO 410.1:** Understand the concept of simulation and study the Monte Carlo method of simulation nuclear radioactivity. **CLO 410.2:** Understand the dynamics of logistic equations and study of damped and driven pendulum. **CLO 410.3:** Solve the transcendental equations using different methods. **CLO 410.4:** Learn about different factors affecting the outcome of a programme.		
Credits	Theory	Practical	Total
	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	

PartB-Contentsofthe Course	**Contact Hours**
Practicals 1. Simulation of Nuclear Radioactivity by Monte Carlo Technique. 2. Dynamics of logistic equations. 3. Dynamics of damped driven pendulum 4. Find the rate of convergence of regula-falsi and Newton-Raphson method. 5. Effect of initial guess values and tolerance to convergence. 6. Study of the growth of error in Euler's method with step size. 7. Accuracy versus number of function evaluations for Trapezoidal rule.	120

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8. Accuracy versus number of function evaluations for Simpson's 1/3rd rule.
Part C-Learning Resources
Recommended Books/e-resources/LMS: 1. Numerical python by Robert Johnsson. 2. Learn Python programming by Fabrizio Romano. 3. Introduction to computing and problem solving using Python by Balaguruswamy. 4. Introductory methods of numerical Analysis by S. S. Sastry. 5. Computer Oriented Numerical Method by V. Rajamana. 6. Numerical Computational Methods by P B Patil and U. P. Verma.

DEC: Electronics-II

CourseLearningOutcomes (CLO) After completing this course, the learner will be able to:	**CLO 410.1:** Design and understand the operations of ripple counters and 4 bit shift registers. **CLO 410.2:** Design and understand the operation of various flip-flops. **CLO 410.3:** Design and understand the operations of astable and monostablemultivibrators using IC-555 timer. **CLO 410.4:** Explain the operations of A/D and D/A convertors. Also able to draw V-I characteristics of FET and understand the effect of negative feedback on gain.		
Credits	Theory	Practical	Total
	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	

PartB-Contentsofthe Gourse	
Practicals	**Contact Hours**
1. To study Ripple Counter. 2. To study 4 bit Shift Register. 3. Flip-Flops: RS, Clocked RS, JK, Master slave JK, D and T types. 4. 8 bit A/D converter: Verification of truth table 5. 8 bit D/A converter: Verification of truth table 6. FET: Study of static drain characteristics and calculations of various parameters. 7. Monostable and astablemultivibrator circuits using IC-555 timer. 8. Negative feedback Amplifiers: Measurement of gain vs. frequency.	120
PartC-Learning Resources	
Recommended Books/e-resources/LMS: 1. Integrated Electronics by J. Millman and C. C. Halkias 2. Pulse, digital and switching waveforms by J. Millman and H. Taub 3. Micro Electronics by J MillmanandAGrabel. 4. Fundamentals of digital circuits by Anand Kumar	

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5. Electronics for Scientists and Engineers: Devices, Circuits and Systems by TV Viswanathan, GK Mehta and V Rajaraman

DEC: Material Science—II

CourseLearningOutcomes (CLO) After completing this course, the learner will be able to:	**CLO 410.1:** Have understanding of X-ray diffractometer and use it to record and analyze the XRD pattern of a crystalline substance. Further use of this technique to compute particle size and lattice strain. **CLO 410.2:** Ascertain the magnetic nature of a given material by measuring its magnetic susceptibility. **CLO 410.3:** Grasp the concept of ferroelectricity and study the variation of dielectric constant with temperature for given ferroelectric material. Learn about solar cell and understand the effect of light intensity and temperature on its I-V characteristics. **CLO 410.4:** Learn and measure the characteristics of a thermo-luminescent material. Understand thermal properties of materials. Compute the chemical states and chemical shift from XPS spectra		
Credits	Theory	Practical	Total
	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	

PartB-Contentsofthe Course

Practicals	Contact Hours
1. Determination of particle size and lattice strain using XRD. 2. Magnetic susceptibility of hydrated copper sulfate. 3. Transition temperature of a ferroelectric material. 4. Spectral response measurement of solar cell. 5. Electron paramagnetic resonance experiment. 6. Dependence of solar cell I-V characteristics on light intensity and temperature. 7. Thermo-luminescence studies. 8. Study of Thermal properties of given crystal (specific heat, thermal expansion, thermal conductivity) 9. XPS data analysis: Finding chemical states and chemical shift from XPS spectra.	120

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PartC-Learning Resources			

Recommended Books/e-resources/LMS:

1. Material Science by J. C. Anderson, K. D. Leaver, J. M. Alexander and R. D. Rawlings.
2. Mechanical Metallurgy by G. E. Dieter.
3. Ion Implantation by G. Dearnally.
4. Fundamentals of Surface and Thin Film Analysis by L. C. Feldman and J. W. Mayer.
5. Surface Analysis Methods in Material Science by D. J. O'Connor, B. A. Sexton and R. St. C. Smart (Eds), Springer Series in Surface Sciences 2023.

SuggestedEvaluationMethods			
InternalAssessment: 30		**End Term Examination: 70**	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/Demonstration/Viva-voce/Lab records etc.:	25		

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Session: 2025-26 (As per scheme 2024-25)			
PartA - Introduction			
Name of the Programme	M.Sc. Physics		
Semester	4th		
Name of the Course	Space Science and Sensors		
Course Code	M24-PHY-411		
Course Type	EEC		
Level of the course (As per Annexure-I	500-599		
Pre-requisite for the course (ifany)	--		
CourseLearningOutcomes (CLO) After completing this course, the learner will be able to:	**CLO411.1:**Understanding of Astronomical model, basic principles involved, remote sensing, GIS **CLO 411.2:**Understand the fundamentals of the astronomical gravity, Sun, Earth Moon atmosphere and basics of tidal forces **CLO411.3:** Understand the thermodynamics of star, stellar, and able to calculate mass of white dwarf. **CLO 411.4:** Understand the basics of different sensors used in space science and principal behind them.		
Credits	Theory	Practical	Total
	2	0	2
Teaching Hours per week	2	0	2
Internal Assessment Marks	15	0	15
End Term Exam Marks	35	0	35
Max. Marks	50	0	50
Examination Time	3 hours		

PartB-Contentsofthe Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unitand the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Introduction to Space Science:** Solar System: geocentric model; heliocentric model; Kepler's laws of planetary motions - Galileo's pioneering work - length and time measurements; Remote sensing: Definition, Principle and Physical basis; Interaction ofEM radiations with earth's surface and atmosphere; Introduction to Geographical Information System (GIS), components and functions of GIS, Concept of raster and vector data.	7
II	**Sun, Earth and Moon systems:** Motion of the Moon around the Earth, Falling bodies, Halley's comet; importance of gravity as a force in astronomy; Physics of the Sun, sunspots, Babcock model of sunspot	7

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	formation, solar atmosphere –chromosphere and Corona; Thermonuclear reactions; discovery of Neptune and Pluto; asteroid belt, meteors, and comets; Tidal forces and the oceanic tides; precession of equinox and change of seasons.	
III	**Stars and Stellar:** Stars—the type, structure, evolution and stability; Stellar structure and evolution- evolution of low mass stars and high mass stars; white dwarfs - structure and stability, Realms of thermodynamics, statistical mechanics and special relativity, Theory of Fowler, Chandrasekhar and Eddington for white Dwarf; Chandrasekhar's mass limit. Introduction to supernova and neutron stars; supernova explosion; pulsars.	8
IV	**Introduction to Sensors for space:** Piezoelectric MEMS sensor, thermistor sensors; Charge Coupled Detectors (CCD), Complimentary Metal-Oxide Semiconductor (CMOS) imaging sensors or CMOS Imaging Sensors (CIS), long-wave infrared detectors, X-ray Detectors for space (LWIR), Short Wave Infrared Band (SWIR) and a Modular Opto-electronic Scanner (MOS), Wide Field Sensor (WiFS), Ultraviolet sensors for space, Solar Wind Electron Energy Probe (SWEEP) and the Solar Wind lon Composition Analyzer (SWICAR).	
	Total Contact Hours	30

SuggestedEvaluationMethods

InternalAssessment: 15		End Term Examination: 35	
➢ **Theory**	**15**	➢ **Theory**	**35**
• Class Participation:	4	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	4		
• Mid-Term Exam:	7		

PartC-Learning Resources

Recommended Books/e-resources/LMS:

1. Astronomy, The Evolving Universe, M. Zeilik (Cambridge University Press, 2002)
2. Introduction to Astronomy & Cosmology, I. Morrison (Wiley, 2008)
3. Remote Sensing and image interpretation (John Wiley & sons). T.M. Lillesand and R.W. Kiefer
4. Remote Sensing Principles and interpretation (WH Freeman Company. F.F. Reeds
5. Remote Sensing for Earth Resources (AEG publication), D.P. Rao
6. Principles of Remote sensing (ELBS London). P. J. Kuran
7. Fundamental Astronomy, H. Karttunen et al. (Springer, 2003)
8. Solar Astrophysics, P. V. Foukal (Wiley-VCH, 2004)
9. Fundamentals of Solar Astronomy, A. Bhatnagar& W.C. Livingston (WorldScientific, 2005)
10. The Physical Universe, Frank Shu (University Science Books, 1982)
11. Cosmology: The Science of the Universe, Edward Harrison (Cambridge UniversityPress, 2000)
12. From Black Clouds to Black Holes, J. V. Narlikar (World Scientific, 1985)
13. Archeoastronomy- Introduction to the Science of Stars and Stones, GiulioMagli (Springer, 2016)
14. Universe, R. A. Freedman & W. J. Kaufmann (W. H. Freeman & Co., 2008)
15. Statistical Mechanics by R. K. Patharia
16. Micro sensors: Principles and Applications, J. W. Gardner (John Wiley, 1994)
17. Sensor Technology and Devices, L. R. Ristic (Artech House publishers, 1994)