REVISED SYLLABI AND SCHEME OF EXAMINATIONS FOR

M.Sc. Physics

(Based on Curriculum and Credit Framework for PG Programs under NEP)

WITH EFFECT FROM THE SESSION 2026-27

This Scheme and Syllabi will also be applicable for the students admitted in 2025-26 from Semester 3rd onwards.

MAHARSHI DAYANAND UNIVERSITY ROHTAK (HARYANA)

Structure for 2 year Post Graduate Programme

	Semester	Discipline-Specific Courses (DSC)	Skill Enhancement Courses (SEC) / Vocational Courses (VOC)/ Internship	Research thesis/project	Total Credits
	First year of 2 Year PG program (NHEQF Level 6)				
	I	DSC 1 @ 4 credits	SEC1/VOC 1/Internship 1 @ 4 credits	---	24
		DSC 2 @ 4 credits			
		DSC 3 @ 4 credits			
		DSC 4 @ 4 credits			
		DSC 5 @ 4 credits			
	II	DSC 6 @ 4 credits	SEC2/VOC2/Internship 2 @ 4 credits	---	24
		DSC 7 @ 4 credits			
		DSC 8 @ 4 credits			
		DSC 9 @ 4 credits			
		DSC 10 @ 4 credits			
Students who exit after first year on completion of 48 credits will be awarded PG Diploma in concerned discipline					
Second year of two year PG program (NHEQF Level 6.5) (STUDENT SHOULD SELECT ANY ONE OPTION FOR THE SECOND YEAR OF 2 YEAR PG PROGRAM)					
Only Course Work					
Option 1	III	DSC 11 @ 4 credits	SEC 3/Internship 3/ Project Work 1 @ 4 credits	---	24
		DSC 12 @ 4 credits			
		DSC 13 @ 4 credits			
		DSC 14 @ 4 credits			
		DSC 15 @ 4 credits			
	IV	DSC 16 @ 4 credits	SEC4/Internship 4/ Project Work 2 @ 4 credits	---	24
		DSC 17 @ 4 credits			
		DSC18 @ 4 credits			
		DSC19 @ 4 credits			
		DSC20 @ 4 credits			
Course work and Research					
Option 2	III	DSC 11 @ 4 credits	SEC 3/Internship 3 @ 4 credits	---	24
		DSC 12 @ 4 credits			
		DSC 13 @ 4 credits			
		DSC 14 @ 4 credits			
		DSC 15 @ 4 credits			
	IV	--	SEC4/Internship 4 @ 4 credits	Research thesis/project @20 credits	24

Only Research (only for the students who have completed 3 Years Bachelor's Program)					
	Semester	**Discipline-Specific Courses (DSC)**	**Skill Enhancement Courses (SEC) / Vocational Courses (VOC)/ Internship**	**Research thesis/project**	**Total Credits**
Option 3	**III**	--	**SEC3/Internship 3 @ 4 credits**	**20 credits***	**24**
	IV	--	**SEC4/Internship 4 @ 4 credits**	**20 credits****	**24**

Note:

*****The students who opted Option 3 should submit a project report/synopsis of atleast 50 pages comprising of Literature survey, identification of Research Problem, Plan of work, methodology as well as practical work (if any) at the end of 3rd semester and the same will be evaluated by internal and external examiners.

**The students should continue the research work in 4th semester based on the project work/synopsis submitted at the end of 3rd semester. The final thesis/project report will be evaluated by the internal and external examiners.

Structure for 1 year Post Graduate Programme (2nd year of 2 Year PG Program)

	Semester	Discipline-Specific Courses (DSC)	Skill Enhancement Courses (SEC) / Vocational Courses (VOC)/Internship	Dissertation/ Project work	Total Credits
(STUDENT SHOULD SELECT ANY ONE OPTION)					
Only Course Work					
Option 1	**I (Semester III of 2 year PG Program)**	**DSC 11 @ 4 credits** **DSC 12 @ 4 credits** **DSC 13 @ 4 credits** **DSC 14 @ 4 credits** **DSC 15 @ 4 credits**	**SEC 3/Internship 3/ Project Work 1 @ 4 credits**	**---**	**24**
	II (Semester III of 2 year PG Program)	**DSC 16 @ 4 credits** **DSC 17 @ 4 credits** **DSC18 @ 4 credits** **DSC19 @ 4 credits** **DSC20 @ 4 credits**	**SEC4/Internship 4/ Project Work 2 @ 4 credits**	**---**	**24**
Course work and Research					
Option 2	**I (Semester III of 2 year PG Program)**	**DSC 11 @ 4 credits** **DSC 12 @ 4 credits** **DSC 13 @ 4 credits** **DSC 14 @ 4 credits** **DSC 15 @ 4 credits**	**SEC 3/Internship 3 @ 4 credits**	**---**	**24**
	II (Semester III of 2 year PG Program)	**--**	**SEC4/Internship 4 @ 4 credits**	**Dissertation/ Project work @ 20 credits**	**24**

Type of Course			**Credits Distribution**			**Total Credits**	**Workload**			**Total Workload**	**Marks**				
	Nomenclature of Course	**Course Code**	**L**	**T**	**P**		**L**	**T**	**P**		**Theory**		**Practical**		**Total Marks**
											Internal	**External**	**Internal**	**External**	
Semester I (Session 2026-27)															
DSC 1 @ 4 credits	Mathematical Physics	24PHY201DS01	03	01	0	04	03	01	0	04	30	70	-	-	100
DSC 2 @ 4 credits	Classical Mechanics	24PHY201DS02	03	01	0	04	03	01	0	04	30	70	-	-	100
DSC 3 @ 4 credits	Quantum Mechanics –I	24PHY201DS03	03	01	0	04	03	01	0	04	30	70	-	-	100
DSC 4 @ 4 credits	Physics of Electronic Devices	24PHY201DS04	03	01	0	04	03	01	0	04	30	70	-	-	100
DSC 5 @ 4 credits	Practical: General Physics -I	24PHY201DS05	0	0	04	04	0	0	08	08	-	-	30	70	100
SEC1/VOC 1/ Internship 1 @ 4 credits	Practical: Electronics - I	24PHY201SE01	0	0	04	04	0	0	08	08	-	-	30	70	100
Semester II (Session 2026-27)															
DSC 6 @ 4 credits	Statistical Mechanics	24PHY202DS01	03	01	0	04	03	01	0	04	30	70	-		100
DSC 7 @ 4 credits	Quantum Mechanics -II	24PHY202DS02	03	01	0	04	03	01	0	04	30	70	-		100
DSC 8 @ 4 credits	Atomic & Molecular Physics	24PHY202DS03	03	01	0	04	03	01	0	04	30	70	-		100
DSC 9 @ 4 credits	Solid State Physics	24PHY202DS04	03	01	0	04	03	01	0	04	30	70	-		100
DSC 10 @ 4 credits	Practical:	24PHY202DS05	0	0	04	04	0	0	08	08	-	-	30	70	100

	General Physics -II													
SEC2/VOC2/ Internship 2 @ 4 credits	Practical: Electronics - II	24PHY202SE01	0	0	04	04	0	0	08	08	-	-	30	70	100

Type of Course			Credits Distribution			Total Credits	Workload			Total Workload	Marks				
	Nomenclature of Course	Course Code	L	T	P		L	T	P		Theory		Practical		Total Marks
											Internal	External	Internal	External	
Semester III (Session 2027-28) **Option-I**															
DSC 11 @ 4 credits	Nuclear & Particle Physics	25PHY203DS01	03	01	0	04	03	01	0	04	30	70	-		100
DSC 12 @ 4 credits	Electrodynamics and Wave Propagation	25PHY203DS02	03	01	0	04	03	01	0	04	30	70	-		100
DSC 13 @ 4 credits	Condensed Matter Physics – I Or Electronics - I Or Advanced Spectroscopy - I	25PHY203DS03 25PHY203DS04 25PHY203DS05	03	01	0	04	03	01	0	04	30	70	-		100
DSC 14 @ 4 credits	Computational Physics –I Or Radiation Physics – I Or Experimental Techniques - I	25PHY203DS06 25PHY203DS07 25PHY203DS08	03	01	0	04	03	01	0	04	30	70	-		100
DSC 15 @ 4 credits	Practical: General Physics–III	25PHY203DS09	0	0	04	04	0	0	08	08	-	-	30	70	100
SEC 3/Internship 3/ Project Work 1 @ 4 credits	Practical: General Physics–IV	25PHY203SE01	0	0	04	04	0	0	08	08	-	-	30	70	100
Semester IV (Session 2027-28) **OPTION 1**															
DSC 16 @ 4 credits	Physics of Laser and	25PHY204DS01	03	01	0	04	03	01	0	04	30	70	-		100

	Laser Applications														
DSC 17 @ 4 credits	Physics of Nanomaterials	25PHY204DS02	03	01	0	04	03	01	0	04	30	70	-		100
DSC18 @ 4 credits	Condensed Matter Physics – II Or Electronics - II Or Advanced Spectroscopy - II	25PHY204DS03 25PHY204DS04 25PHY204DS05	03	01	0	04	03	01	0	04	30	70	-		100
DSC19 @ 4 credits	Computational Physics – II Or Radiation Physics – II Or Experimental Techniques - II	25PHY204DS06 25PHY204DS07 25PHY204DS08	03	01	0	04	03	01	0	04	30	70	-		100
DSC20 @ 4 credits	Practical: Condensed Matter Physics Or Practical: Electronics Or Practical: Advanced Spectroscopy	25PHY204DS09 25PHY204DS10 25PHY204DS11	0	0	04	04	0	0	08	08	-	-	30	70	100
SEC4/Internship 4/ Project Work 2 @ 4 credits	Practical: Computational Physics Or Practical: Radiation Physics Or Practical: Experimental Techniques	25PHY204SE01 25PHY204SE02 25PHY204SE03	0	0	04	04	0	0	08	08	-	-	30	70	100
Semester III (Session 2027-28) **OPTION 2**															
DSC 11 @ 4 credits	Nuclear & Particle Physics	25PHY203DS01	03	01	0	04	03	01	0	04	30	70	-		100

DSC 12 @ 4 credits	Electrodynamics and Wave Propagation	25PHY203DS02	03	01	0	04	03	01	0	04	30	70	-		100
DSC 13 @ 4 credits	Physics of Laser and Laser Applications	25PHY204DS01	03	01	0	04	03	01	0	04	30	70	-		100
DSC 14 @ 4 credits	Physics of Nanomaterials	25PHY204DS02	03	01	0	04	03	01	0	04	30	70	-		100
DSC 15 @ 4 credits	Practical: General Physics–III	25PHY203DS09	0	0	04	04	0	0	08	08	-	-	30	70	100
SEC 3/Internship 3/ Project Work 1 @ 4 credits	Practical: General Physics - IV	25PHY203SE01	0	0	04	04	0	0	08	08	-	-	30	70	100
Semester IV (Session 2027-28) **OPTION 2**															
SEC4/ Internship 4 @ 4 credits	Characterization Techniques	25PHY204SE04	02	-	02	04	02	-	04	06	15	35	50		100
Research thesis/ project @20 credits	Dissertation/ Research Thesis/ Project	25PHY204PD01	-	-	-	20	-	-	-	-	-	-	150	350	500

L: Lecture; T: Tutorial; P: Practical

- The Practical shall consist of the following components:

Total Marks: 50	**Total Marks: 100**
• Attendance: 5 Marks	• Attendance: 5 Marks
• Practical Assignments/ Practical File: 10 Marks	• Practical Assignments/ Practical File: 25 Marks
• Experiment Performed & Viva-voce: 35 Marks	• Experiment Performed & Viva-voce: 70 Marks

Syllabi for Post Graduate Program in Physics

Semester-I
Session: 2026-27

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Mathematical Physics	**Course Code**	24PHY201DS01
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:
Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: The students would get sufficient exposure /understanding of the linear vector space and applications of matrices to physical problems

CO2: The students would be able to solve problems based on differential equations

CO3: The analysis of special functions would equip a student for effective tackling of specific problems.

CO4: The students would be able to realize various applications with proper understanding of series expansion and integral transforms

Unit 1:
Vector spaces, Norm of a Vector, Linear independence & dependence, Basis and dimension, Isomorphism of Vector spaces, Scalar/Inner product of vectors, Orthonormal basis, Gram-Schmidt Orthogonalization process, Linear operators, Matrices, Cayley-Hamiltion Theorem, Inverse of matrix, Orthogonal, Unitary and Hermitian matrices, Eigenvalues and eigenvectors of matrices, Similarity transformation, Matrix diagonalization, Simultaneous diagonalization and commutativity

Unit 2:
Second order linear differential equation with variable coefficients, Ordinary point, Singular point, Series solution around an ordinary point, Series solution around a regular singular point; the method of Frobenius, Wronskin and getting a second solution, Solution of Legendre's equation, Solution of Bessel's equation, Solutions of Laguerre and Hermite's equations

Unit 3:
Special functions, Generating functions for Bessel function of integral order $J_n(x)$, Recurrence relations, Integral representation; Legendre polynomials $P_n(x)$, Generating functions for $P_n(x)$, Recurrence relations, orthogonality, Rodrigue's Relation; Hermite Polynomials; Generating functions, Rodrigue's relation &orthogonality for Hermite polynomials; Laguerre polynomials; Generating function and Recurrence relations,

Orthogonality, Rodrigue's Relation, The Gamma Function, The Dirac – Delta Function

Unit 4:

Integral transform, Laplace transform, Properties of Laplace transforms such as first and second shifting property, Laplace Transform of Periodic Functions, Laplace transform of derivatives, Laplace Transform of integrals, Inverse Laplace Transform by partial fractions method, Fourier series, Evaluation of coefficients of Fourier series Cosine and Sine series, Applications of Fourier Series, Fourier Transforms, Fourier sine Transforms, Fourier cosine Transforms, Fourier transform of derivatives, Applications of Fourier Transforms

References:

1. Mathematical Physics by P.K. Chattopadhyay (T)
2. Mathematical Physics by B. S. Rajput
3. Matrices and Tensors for Physicists, by A. W Joshi
4. Mathematical Physics by Mathews and Walkers
5. Mathematics for Physicists by Mary L Boas

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Classical Mechanics	**Course Code**	24PHY201DS02
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:

Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Student would be able to describe and understand the motion of a mechanical system using Lagrange and Hamilton formalisms.

CLO2: Students would become able to understand the concepts of central force motion and moving co-ordinate systems.

CLO3: Student would get basic ideas about the theory of small oscillations and use of Poisson's bracket which will lead to understand the concepts of quantum mechanics.

Unit 1:

Survey of Elementary Principles and Lagrangian Formulation: Newtonian mechanics of one and many particle systems, Conservation laws, Constraints and their classification, Generalized coordinates and momenta, Principle of virtual work, D' Alembert's principle and Lagrange's equation, Velocity dependent potentials and dissipation function, Simple applications of Lagrangian formulation, Cyclic coordinates, Symmetries of space and time and conservation laws, Invariance of Lagrangian under Galilean transformation

Unit 2:

Moving coordinate systems and Motion in a central force field: Rotating frames, inertial forces, terrestrial applications of Coriolis force, two body problem: Reduction to equivalent one body problem, Central force definition and characteristics, the equation of motion and first integrals, differential equation for the orbit, general analysis of orbits, condition for closure and stability of circular orbits, Kepler's laws and equations, Rutherford scattering.

Unit 3:

Legendre Transformation and Hamilton's equations of motion, Some techniques of calculus of variation, Variational principle, Hamilton's principle from D'Alembert's principle, Lagrange's equation from Hamilton's principle, Hamilton's equations from variational principle, variation and end points, Principle of least action and its forms, Hamilton-Jacobi equation and their solutions, Use of Hamilton-Jacobi method for the solution of Harmonic oscillator problem, Hamilton's principle function, Hamilton's characteristic function and their properties

Unit 4:

Canonical transformations, Generating functions, Properties of Poisson bracket, Equation of motion in Poisson bracket, Angular momentum and Poisson bracket relations, Jacobi identity, Invariance of Poisson brackets using canonical transformations, Potential Energy and equilibrium: Stable, unstable and neutral equilibrium, One-dimensional Oscillator, Two coupled oscillators: Solution of differential equation to find normal coordinates and normal modes, Theory of small oscillations, Examples of coupled oscillators: Two coupled pendulum, double pendulum, Free vibrations of a linear triatomic molecule.

References:

1. Classical Mechanics by N C Rana and P S Joag (Tata McGraw Hill, 1991)
2. Classical Mechanics by H Goldstein (Addison Wesley, 1980)
3. Mechanics by A. Sommerfeld (Academic Press, 1952)
4. Introduction to Dynamics by I Perceival and D Richards (Cambridge Univ. Press, 1982)

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Quantum Mechanics –I	**Course Code**	24PHY201DS03
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:

Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Student would be able to understand the concepts of operators in Quantum mechanics.
CLO2: Students would be able to apply Pauli spin matrices to explain angular momentum.
CLO3: Students would be capable to solve problems such as hydrogen atom.
CLO4: Students can determine energies and wave functions of first and second order.

Unit 1:

General formalism of Quantum Mechanics: States and operators; Representation of States and dynamical variables; Linear vector space; Bra Ket notation, Linear operators; Orthonormal set of vectors, Completeness relation; Hermitian operators, their eigenvalues and eigenvectors, The fundamental commutation relation; Commutation rule and the uncertainty relation; Simultaneous eigenstates of commuting operators; The unitary transformation; Dirac delta function; Relation between kets and wave functions; Matrix representation of operators; Solution of linear harmonic oscillator problem by operator methods

Unit 2:

Angular momentum operator: Angular momentum operators and their representation in spherical polar co-ordinates; Eigenvalues and eigenvectors of L^2, spherical harmonics; Commutation relations among L_x L_y L_z; Rotational symmetry and conservation of angular momentum; Eigenvalues of J^2 and J_z and their matrix representation; Pauli spin matrices; Addition of angular momentum

Unit 3:

Solution of Schrodinger equation for three dimensional problems: The three-dimensional harmonic oscillator in both Cartesian and spherical polar coordinates, Eigen values, Eigen functions and the degeneracy of the states; Solution of the hydrogen atom problem, the eigenvalues, Eigen functions and the degeneracy

Unit 4:

Perturbation Theory: Time independent perturbation theory; Non degenerate case, the energies and wave functions in first order the energy in second order; Anharmonic perturbations of the form λx^3 and λx^4 ; Degenerate perturbation theory; Stark effect of the first excited state of hydrogen.

References:

1. Quantum Mechanics by Ghatak and Loknathan
2. Quantum Mechanics by Powell and Craseman
3. Quantum Mechanics by S. Gasiorowicz
4. Quantum Mechanics by A.P. Messiah
5. Modern Quantum Mechanics by J.J. Sakurai
6. Quantum Mechanics by L.I. Schiff
7. Quantum Mechanics by Mathews and Venkatesan

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Physics of Electronic Devices	**Course Code**	24PHY201DS04
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:

Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Students would get familiarity with semiconductor materials and charge transport in semiconductors

CLO2: Students would be able to appreciate the functioning and applications of various optoelectronic and memory devices.

CLO3: Students would be able to explain the basic physics and application of different transistor types.

CLO4: Students having familiarization with negative resistance devices and will be in a position to design switching circuits involving these devices.

Unit 1:

Charge carriers in semiconductors: Energy bands, metals, Semiconductors and insulators, Direct and indirect band gap semiconductors, Variation of energy bands with alloy composition, Electrons and holes, effective mass, Intrinsic and extrinsic semiconductors, Concept of Fermi level, Electron and hole concentration at equilibrium, Temperature dependence of carrier concentrations, Compensation and space charge neutrality, Conductivity and mobility, Effect of temperature and doping on mobility, Hall effect, Invariance of Fermi level

Unit 2:

Carrier transport in semiconductors: Optical absorption and luminescence, Carrier lifetime and photoconductivity, Direct/indirect recombination of electrons and holes, Traps and defects, Steady state carrier generation, Quasi Fermi levels, Diffusion and drift of carriers, Diffusion and recombination, Diffusion length, Haynes Shockley experiment, Gradient in quasi-Fermi level, External and internal photoelectric effect

Unit 3:

Diode physics and optoelectronic devices: P-N junction diode: Basic structure, Energy band diagram, Built-in potential, Electric field, Space charge width and qualitative description of current flow, Derivation of diode current equation, Zener diode: breakdown mechanisms, Voltage regulator circuit, Power diode, Varactor diode, Optoelectronic devices: Vacuum photodiode, Photo-multipliers tube, P-N junction photodiode, Pin photodiode, Avalanche photodiode, Phototransistor, Solar cell, Light emitting diode (LED), Diode laser: Condition for laser action and optical gain

Unit 4:

Transistors: Bipolar junction transistor (BJT), Transistor operating modes, Transistor action, Transistor biasing configurations and characteristics, Field effect transistors: Junction field effect transistor (JFET), Metal oxide semiconductor field effect transistor (MOSFET), Negative resistance devices: Tunnel diode, Backward diode, Uni-junction transistor, p-n-p-n devices and their characteristics, Silicon controlled rectifier and switch and their characteristics.

References:

1. Semiconductor Devices - Physics and Technology by S.M. Sze (Wiley).
2. Solid State Electronic Devices by Ben G. Streetman (PHI).
3. Semiconductor Physics and Devices by Donald A Neamen (Tata-McGraw Hill).
4. Integrated Electronics by J. Millman and C.C. Halkias (Tata-McGraw Hill).
5. Semiconductor Devices by Kanaan Kano (PHI).
6. Semiconductor Optoelectronic Devices by Pallab Bhattacharya (Pearson)

7. Semiconductor Device Fundamentals by Robert F Pierret (Addison-Wesley).
8. Electronic Devices and Circuit Theory by Robert L. Boylestad (Pearson).

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Practical: General Physics -I	**Course Code**	24PHY201DS05
Hours per Week	08	**Credits**	04
Maximum Marks	Internal=30 External=70 Total =100		

Note: Out of the list of experiments given below one experiment will be allotted through lottery method to each student on the day of examination to perform and then followed by Viva-voce.

Course Learning Outcomes (CLO):

CLO1: Students would be able to determine the values of Stefan's constant, Boltzmann constant and e/m ratio of electron and experimental errors in each case.

CLO2: Students would be able to understand magnetization and related aspects in a ferromagnetic material.

CLO3: Students get familiarized with advanced spectroscopy.

CLO4: Students would be able to understand the different harmonics and their amplitudes in a Fourier series experimentally which provide direct connect between theory and experiment.

List of Experiments

1. To determine the dielectric constant of polar and non-polar liquids
2. To determine the Magnetic susceptibility of a solid sample.
3. To study B-H curve of a given ferrite sample and find energy loss in case of ferrite Core.
4. Stefan's constant by the black copper radiation plates (Electrical Method).
5. To determine the heat capacity of solids
6. To verify the existence of different harmonics and measure their relative amplitudes using Fourier Analysis kit
7. To study of dielectric constant as a function of temperature and determine the Curie temperature
8. To determine the dielectric constant of different solid samples
9. Study of lead tin phase diagram
10. To determine Boltzmann Constant (k) using I-V characteristics of Si/Ge P-N junction diode
11. Dissociation Energy of I_2 molecule
12. Measurement of minority carrier lifetime using Haynes Shockley experiment

Note: Out of the list as above, a student has to perform atleast 08 (eight) practical's in the semester

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Practical:	**Course Code**	24PHY201SE01

	Electronics-I		
Hours per Week	08	**Credits**	04
Maximum Marks	Internal=30 External=70 Total =100		

Note: Out of the list of experiments given below one experiment will be allotted through lottery method to each student on the day of examination to perform and then followed by Viva-voce.

Course Learning Outcomes (CLO):

CLO1: The students would get hands on experience on experiments and relation to theory

CLO2: Theoretical results for different networks matched with experiments would enable students for complex circuits

CLO3: The students would get equipped for applications based on solid state devices

CLO4: The students would be able to differentiate between analog and digital electronics.

List of Experiments

1. Design/study of a Regulated Power Supply.
2. To study the frequency response of a single state negative feedback amplification for various feedback circuit. Negative Feedback (voltage series/shunt and current series/shunt)
3. To study rectifier and filter circuits and draw wave shapes.
4. Study of Network theorems.
5. To study the frequency variation in RC phase shift, Colpitts and Hartley Oscillators.
6. Frequency response of RC coupled Amplifier.
7. To study the characteristics of a junction transition and determination of FET parameters.
8. FET and MOSFET characterization and application as an amplifier.
9. Uni-junction Transistor and its application.
10. Bridge Rectifier using SCR with DC and AC Gate
11. Characteristics and applications of Silicon Controller Rectifier.

Note: Out of the list as above, a student has to perform atleast 08 (eight) practical's in the semester

Semester-II

Session: 2026-27

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Statistical Mechanics	**Course Code**	24PHY202DS01
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:

Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1 The students are able to appreciate cellular nature of phase space and interface of Statistical Mechanics with Thermodynamics

CLO2 Knowledge of ensemble theory would result in greater insight into solutions of various complex problems

CLO3 The students would be able to analyse the peculiar gas behaviour and are in a position to extend the treatment to complex problems

CLO4 The students would be equipped to explore the applications of Ising Model and to understand different approximations.

Unit 1:

Phase space, Ensembles, Liouville theorem, conservation of extension, Equation of motion, Equal a priori probability, Statistical equilibrium, Micro-canonical ensemble, Quantization of phase space, classical limit, symmetry of wave functions effect of symmetry on counting, Various distributions using micro canonical ensemble Entropy of an ideal gas, Equilibrium Conditions, Quasi – Static Process, Entropy of an ideal gas using Micro-canonical Ensemble, Gibbs paradox, Sackur-Tetrode equation, Probability distribution and entropy of a two level system.

Unit 2:

Entropy of a system in contact with a reservoir, Canonical ensemble, Ideal gas in a canonical ensemble, Equipartition of energy, Third law of thermodynamics, Photons, Grand canonical ensemble, Ideal gas in Grand Canonical ensemble, Comparison of various ensembles, Quantum distribution using other ensembles

Unit 3:

Transition from classical statistical mechanics to quantum statistical mechanics, Indistinguishability and quantum statistics, identical particles and symmetry requirements, Bose Einstein statistics, Fermi Dirac statistics, Maxwell Boltzmann statistics. Bose Einstein Condensation, Thermal properties of B.E. gas, liquid Helium, Energy and pressure of F-D gas, Electrons in metals, Thermionic Emission, Saha Theory of Thermal Ionization

Unit 4:

Cluster expansion for a classical gas, Virial equation of state, Van der Waals gas, Phase transition of second kind, Ising Model, Bragg Williams Approximation, Ising Model in one and two dimensions, fluctuations in ensembles, Energy fluctuation in quantum statistics, Concentration fluctuation in quantum statistics, One dimensional random walk, Brownian motion.

References:

1. Statistical Mechanics by K. Huang
2. Statistical Mechanics by B.K. Aggarwal and M. Eisner
3. Statistical Mechanics by R.K. Patharia
4. Statistical Mechanics by Donald A McQuarrie
5. Statistical Mechanics by Avijit Lahiri
6. Statistical Mechanics R Kubo

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Quantum Mechanics –II	**Course Code**	24PHY202DS02

Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:
Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO1: Students would be able to explain ground state of hydrogen and helium molecules.
CLO2: Students get enabled to analyse various transitions and their selection rules.
CLO3: Students would be capable to understand 3D collisions.
CLO4: Students would be capable to calculate spin states of identical particles.

Unit 1:
Variational methods: Ground state of Helium by both variational and perturbation methods; The hydrogen molecule; WKB approximation; Time dependent perturbation theory; Constant perturbation; Harmonic perturbation; Fermi's golden rule; Adiabatic and sudden approximation.

Unit 2:
Semi-classical theory of radiation: Transition probability for absorption and induced emission; Electric dipole transition and selection rules; Magnetic dipole transitions; Forbidden transitions; Higher order transitions; Einstein's coefficients.

Unit 3:
Collision in 3D and scattering: Laboratory and C.M. reference frames; scattering amplitude; Differential scattering cross section and total scattering cross section; The optical theorem; Scattering by spherically symmetric potentials; Partial waves and phase shifts; Scattering by a perfectly rigid sphere and by square well potential; Complex potential and absorption; The Born approximation.

Unit 4:
Identical particles: The principle of indistinguishability; Symmetric and antisymmetric wave functions; Spin and statistics of identical particles; The Slater determinant; The Pauli exclusion principle; Spin states of a two-electron system; States of the helium atom; Collision of identical particles.

References:

1. Quantum Mechanics by Ghatak and Loknathan
2. Quantum Mechanics by Powell and Crassman
3. Quantum Mechanics by S. Gasiorowicz
4. Quantum Mechanics by A.P. Messiah
5. Modern Quantum Mechanics by J.J. Sakurai
6. Quantum Mechanics by L.I. Schiff
7. Quantum Mechanics by Mathews and Venkatensan.

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Atomic and	**Course Code**	24PHY202DS03

	Molecular Physics		
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03

Note:
Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO1: Atomic spectra of one and two electron atoms.
CLO2: The change in behaviour of atoms in external applied electric and magnetic field.
CLO3: Diatomic molecules and their rotational vibrational and rotational vibrational spectra.
CLO4: Energy levels and spectrum in diatomic molecules

Unit 1:
One Electron systems and Pauli principle: Quantum states of one electron atoms, atomic orbitals, Hydrogen spectrum, Pauli principle, spectra of alkali elements, spin orbit interaction and fine structure in alkali spectra, Spectra of two electron systems, equivalent and non-equivalent electrons

Unit 2:
The influence of external fields, Two electron system Hyperfine structure and Line broadening: Normal and anomalous Zeeman effect, Paschen Back effect, Stark effect, Two electron systems, interaction energy in LS and JJ coupling, Hyperfine structure (magnetic and electric, only qualitative)

Unit 3:
Diatomic molecules and their rotational spectra: Types of molecules, Diatomic linear symmetric top, asymmetric top and spherical top molecules, Rotational spectra of diatomic molecules as a rigid rotator, energy levels and spectra of non-rigid rotor, intensity of rotational lines

Unit 4:
Vibrational and Rotational Vibration spectra of Diatomic molecules: Vibrational energy of diatomic molecule, Diatomic molecules as a simple harmonic oscillator, Energy levels and spectrum, Morse potential energy curve, Molecules as vibrating rotator, vibration spectrum of diatomic molecules, PQR Branches

References:
1. Introduction to Atomic and Molecular Spectroscopy by V.K. Jain
2. Introduction to Atomic spectra by H.E. White
3. Fundamentals of molecular spectroscopy by C.B. Banwell
4. Spectroscopy Vol I and II by Walker and Straughen
5. Introduction to Molecular spectroscopy by G. M. Barrow
6. Spectra of diatomic molecules by Herzberg
7. Molecular spectroscopy by Jeanne. L. McHale
8. Molecular spectroscopy by J.M. Brown

9. Spectra of atoms and molecules by P. F. Bemath
10. Modern spectroscopy by J.M. Holias

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Solid State Physics	**Course Code**	24PHY202DS04
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:
Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO1: Differentiate between different lattice types and explain the concept of reciprocal lattice and crystal diffraction using X-rays
CLO2: Explain motion of electron in periodic lattice of solids under different binding conditions, concept of energy band and effect of same on electrical properties.
CLO3: Lattice vibrations in solids and identity different types of defects in crystals
CLO4: Explain various types of magnetic phenomena, superconductivity, Physics behind them and their possible applications.

Unit 1:
Crystalline solids, Lattice, The basis, Lattice translation vectors, Direct lattice, Two and three dimensional Bravais lattice, Conventional units cells of FCC, BCC, NaCl, CsCl, Diamond and cubic ZnS, Primitive lattice cell of FCC, BCC and HCP, Packing fraction: Simple Cubic, BCC, FCC, HCP and diamond structures, Interaction of x-rays with matter, Absorption of x-rays, elastic scattering from a perfect lattice, The reciprocal lattice and its application to diffraction techniques, Ewald's construction, The Laue, Powder and rotating crystal methods, Atomic form factor, Crystal structure factor and intensity of diffraction maxima, Crystal structure factors of BCC, FCC, monatomic diamond lattice, polyatomic CuZn.

Unit 2:
Vibration of one-dimensional mono and diatomic chains, Phonon momentum, Density of normal modes in one and three dimensions, Quantization of lattice vibrations, Measurement of phonon dispersion using inelastic neutron scattering, Point defects, Line defects and planer (stacking) faults, Fundamental ideas of the role of dislocation in plastic deformation and crystal growth, Observation of imperfection in crystals, X-rays and electron microscopic techniques.

Unit 3:
Electron in periodic lattice, Block theorem, Kronig-Penny model and band theory, Classification of solids, Effective mass, Weak-binding method and its application to linear lattice, Tight-binding method and its application to Simple cubic, BCC and FCC crystals, Concepts of holes, Fermi surface: Construction of Fermi surface in two-dimension, de Hass

van Alfen effect, Cyclotron resonance, Magneto-resistance.

Unit 4:

Weiss Theory of Ferromagnetism Heisenberg model and molecular field theory of ferromagnetism of spin waves and Magnons, Curie-Weiss law for susceptibility. Ferri and Anti Ferro-magnetic order, Domains and Block wall energy, Occurrence of superconductivity, Meissner effect, Type-I and Type-II superconductors, Heat capacity, Energy gap, Isotope effect, London equation, Coherence length, Postulates of BCS theory of superconductivity, BCS ground state, Persistent current. High temperature oxide super conductors (introduction and discovery).

References:

1. Verma and Srivastava: Crystallography for Solid State Physics
2. Azaroff: Introduction to Solids
3. Omar: Elementary Solid-State Physics
4. Ashcroft & Mermin: Solid State Physics
5. Kittel: Solid State Physics
6. Chaikin and Lubensky: Principles of Condensed Matter Physics
7. H. M. Rosenberg: The solid State.

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Practical: General Physics -II	**Course Code**	24PHY202DS05
Hours per Week	08	**Credits**	04
Maximum Marks	Internal=30 External=70 Total =100		

Note: Out of the list of experiments given below one experiment will be allotted through lottery method to each student on the day of examination to perform and then followed by Viva-voce.

Course Learning Outcomes (CLO):

CLO1: Students would be able to determine the values of Ionization potential of Hg, Planks and e/m ratio of electron and experimental errors in each case.

CLO2: Students would be able determine band gap energy of semiconductor crystals

CLO3: Students get familiarized with LEDs

CLO4: Students would be able to understand the working of p-n junction solar cells

CLO5: Students will be able to measure dielectric constant of ferroelectric solids and their ferroelectric transition temperature.

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List of Experiments

1. Determination of ionization potential of mercury
2. Determination of e/m of electron by helical method
3. To study of dielectric constant as a function of temperature and determine the Curie temperature
4. To determine Planck’s Constant (h) by measuring the voltage drop across light-emitting diodes (LEDs) of different colours
5. To determine the value of energy levels using Frank-Hertz experiment

6. Characteristics of Phototransistor
7. To calibrate a prism spectrometer with mercury lamp and hence to find the Cauchy's constants
8. To determine refractive indices of liquids, transparent and translucent solutions and solids using Abbe-refractometer
9. To study the velocity of sound and its variation with temperature using Ultrasonic interferometer.
10. To study the characteristics (illumination, I-V, Power-load, Areal and Spectral characteristics) of a Solar cell
11. To Measure the resistivity of Ge crystal using four probe method at different temperatures and hence find the band gap

Note: Out of the list as above, a student has to perform atleast 08 (eight) practical's in the semester

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Practical: Electronics-II	**Course Code**	24PHY202SE01
Hours per Week	08	**Credits**	04
Maximum Marks	Internal=30 External=70 Total =100		

Note: Out of the list of experiments given below one experiment will be allotted through lottery method to each student on the day of examination to perform and then followed by Viva-voce.

Course Learning Outcomes (CLO):

CLO1: Students will be able to design circuits and verify truth table of different logic gates, flip flops, adders and Subtractor

CLO2: Students will be able to design integrating and differentiating circuits using passive components

CLO3: Students will be able to practically verify the frequency response of single and multistage amplifiers

CLO4: Measurement of various analog circuits and comparison of experimental results with Theoretical analysis enables the student for problem solving.

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List of Experiments

1. Digital I: Basic Logic Gates, NAND and NOR and Flip flops
2. Astable, Monostable and Bistable Multivibraters.
3. Study of Emitter follower/Darlington Pair Amplifier model-C024
4. To study the characteristics and frequency response of a push- pull amplifier
5. To study the characteristics and frequency response of a Chopper Amplifier
6. Wein Bridge and Phase shift oscillator.
7. To study analog voltage comparator circuit
8. To study the frequency response of two stages
    a) Transformer coupled amplifier
    b) Choke coupled amplifier.

9. Integrating & Differentiating Circuits
10. Working of Half & Full Adders
11. Working of Half & Full Subtractor
12. Design of a Common Emitter Transistor Amplifier.
13. Transistor Biasing and Stability.

Note: Out of the list as above, a student has to perform atleast 08 (eight) practical's in the semester

Semester-III (Option – I)
Session: 2027-28

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Nuclear and Particle Physics	**Course Code**	25PHY203DS01
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:
Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO1: Students would be able to realize the nature of nuclear force and nuclear reactions.
CLO2: Students would be able to understand the structure of the nucleus and would be able to find out the spin, parity, magnetic moments etc. of different nuclei.
CLO3: Students would be able to understand different nuclear decays.
CLO4: Students would gain basic knowledge about Elementary Particles and their interactions.

Unit 1:
Two nucleon problem: Common potentials used for calculation of nuclear forces viz. Wigner, Majorana, Bartlett and Heisenberg potentials, The ground state of deuteron, Square well solution for the deuteron, Qualitative features of Nucleon – nucleon scattering, Effective range theory in n – p scattering and Significance of sign of scattering length; Meson theory of nuclear force (Qualitative discussion);Types of nuclear reactions: compound and direct nuclear reactions, Reaction cross – section, Reaction cross-section in terms of partial wave treatment, Balance of mass and energy in nuclear reactions, Q equation and its solution.

Unit 2:
Liquid drop model: Similarities between liquid drop and nucleus, Semi-empirical mass formula, Mass Parabolas (Prediction of stability against β-decay for members of an Isobaric family), Stability limits against spontaneous fission, Merits and limitations of Liquid drop model; Shell model: Experiment evidences for shell effect, Magic numbers, Main assumptions of the single particle shell model, Spin-orbit coupling in single particle shell

model, Estimation of spin, parities and magnetic moments of nuclei by single particle shell model.

Unit 3:

Nuclear Decays: Alpha (α) decay, α- disintegration energy, Range of α-particles, Range – energy relationship for α-particles and Geiger – Nuttall law; Beta decay, Pauli's neutrino hypothesis, Fermi theory of beta decay, Curie plot, selection rules for beta decay, Fermi and Gamow-Teller Transitions, Detection and properties of neutrino; Gamma decay, Multipole transitions in nuclei, Angular momentum and parity selection rules; Internal conversion, Nuclear isomerism.

Unit 4:

Elementary Particle Physics: Classifications of elementary particles: fermions and bosons, particles and antiparticles; Fundamental interactions in nature; Type of interaction between elementary particles: Symmetry and conservation laws; Classification of hadrons: Strangeness, Hypercharge, Gelleman - Nishijima formula, Elementary ideas of CP and CPT invariance; Quark model, Baryon Octet, Meson Octet, Baryon Decuplet, Gell-Mann-Okubo formula for octet and decuplet, the necessity of introducing the colour quantum number, SU (2) and SU (3) multiples (qualitative only).

References:

1. Nuclear Physics Theory and Experiment by R.R. Roy and B.P. Nigam (New Age International (P) Limited, Publishers)
2. Nuclear Physics- An introduction by S B Patel (New Age International (P) Limited, Publishers)
3. Concepts of Modern Physics by Arthur Beiser, S Mahajan, and S Rai Choudhury (Mc Graw Hill Education)
4. Introductory Nuclear Physics by Kenneth S. Krane (Wiley, New York)
5. Introductory Nuclear Physics by Y.R. Waghmare (Oxford – IBH, Bombay)
6. Nuclear Physics, 2nd addition by Kapaln (Narosa, Madras)
7. Introduction to Nuclear Physics by F.A. Enge (Addison-Wesley)
8. Nucleon Interaction by G.E. Brown and A.D. Jackson (North-Holland, Amsterdam)
9. Nuclear and Particle Physics by S L Kakani and Shubhra Kakani (Viva Books)
10. Introduction to High Energy Physics by P.H. Perkins (Addison-Wesley, London, 1982)
11. Introduction to Elementary Particles by D. Griffiths (Harper and Row, New York, 1987).

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Electrodynamics and Wave propagation	**Course Code**	25PHY203DS02
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:

Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Students would be able to formulate and solve electrodynamic problems in relativistic covariant form in four-dimensional space.

CLO2: Students would gain knowledge about electrostatic and magnetic fields produced by static and moving charges in a variety of simple configurations.

CLO3: Would be able to analyse the basics of theory of transmission lines and waveguides.

Unit 1:

Review of four-vector and Lorentz transformation in four-dimensional space; Conservation of charge and four current density; Electromagnetic field tensor in four dimensions and Maxwell's equations; Lorentz invariants of electromagnetic fields; Dual field tensor; Transformation of electric and magnetic field vectors; Covariance of force equation.

Unit 2:

Radiating systems: Field and radiation of a localized source; Oscillating electric dipole; Centre fed linear antenna; Lienard-Wiechert potential; Electric and magnetic fields due to a uniformly moving charge and accelerated charge; Linear and circular acceleration and angular distribution of power radiated.

Unit 3:

Radiative reaction force; Scattering and absorption of radiation; Thompson scattering and Rayleigh scattering; Normal and anomalous dispersion; Ionosphere; Propagation of electromagnetic wave through ionosphere; Reflection of electromagnetic waves by ionosphere; Motion of charged particles in uniform E and B fields; Time varying fields.

Unit 4:

Fields at the surface of and within a conductor; Wave guides; Modes in a rectangular waveguide; Attenuation in waveguides; Dielectric waveguides; Circuit representation of parallel plate transmission lines; Transmission line equations and their solutions; Characteristic impedance and propagation coefficient; Low loss radio frequency and UHF transmission lines.

References:

1. Classical Electrodynamics by J.D. Jackson
2. Introduction to Electrodynamics by D.J. Griffiths
3. Electromagnetic by B.B. Laud
4. Classical Electricity and Magnetism by Panofsky and Phillips
5. Fundamentals of Electromagnetics by M.A. Wazed Miah

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Condensed Matter Physics –I	**Course Code**	25PHY203DS03
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:

Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: The students would be able to understand the bonding in metals, ionic and covalent crystals and also their thermal expansion and thermal conductivity.

CLO2: Proper understanding of various theoretical concepts of optical properties of solids.

CLO3: The students would understand different phenomena, and theoretical analysis of superconducting materials along with their applications in SQUIDs magnetometer.

CLO4: The students would be able to understand the dielectric and ferroelectric properties of solids.

Unit 1:

Difficulties of the classical theory, Free electron model, The Fermi Dirac distribution, Electronic specific heats, Para-magnetism of free electrons, Thermionic and field enhanced emission from metals, Change of work function, The contact potential between two metals, Photo-electric effect, Electrical conductivity of metals: features, Drift velocity and relaxation time, Boltzmann transport equation, Somerfield theory of electrical conductivity, Electron phonon collisions, Electrical conductivity at low temperature, Thermal conductivity of metals and insulators.

Unit 2:

Static dielectric constant, Electronic and ionic polarizabilities, Orientational polarization, Static Dielectric constant of gases and solids, Dielectric constant and polarizability, Clausius-Mossotti relation, Complex dielectric constant and loses, Dielectric relaxation, Classical theory of electronic polarization, Debye equations, Cole-Cole plots and equivalent circuits, Ferroelectrics: Ferroelectric materials, Dipole theory of ferroelectrics, Ionic displacement in $BaTiO_3$ above curie temperature, Ferroelectric domains.

Unit 3:

The optical constants: Index of refraction, Damping constant(k), Characteristic penetration depth (w), Absorbance (a), Reflectivity (r), Transmittance (t) Hagen–Ruben's relation, Atomistic theory of the optical properties: Free electrons with & without damping, Reflectivity, Bound electrons, Discussion of the Lorentz equations, Contributions of free electrons and harmonic oscillators to the optical constants, Quantum mechanical treatment of the optical properties: Absorption of light by inter-band and intra-band transitions, Optical spectra of materials, Dispersion, Brief idea of spectroscopic ellipsometry.

Unit 4:

Ferromagnetism: Classical theory of ferromagnetism, Curie Weis law, Quantum theory ferromagnetism, Exchange energy, origin of domains and domain wall, Magnons: Dispersion relations, Thermal excitation and heat capacity, anti-ferromagnetism: Neel two sub lattice model, anti-ferromagnetic ordering, Ferri-magnetism: spin arrangement and two sub lattice model, Soft and hard magnetic materials and their uses, Colossal and Giant magnetoresistance.

References:

1. Solid State Physics by A. J. Dekker (Macmillan)
2. Introduction to Condensed Matter Physics by K.C. Barua (Narosa)
3. Principle of Electronic Materials and Devices by S. O. Kasap (Tata McGraw Hill)

4. Electronic Properties of Materials by Rolf E. Hummel (Springer)
5. Solid State Physics by Ashcroft &Mermin (Cengage Learning).
6. Introduction to Solid State Physics by Charles Kittel (Wiley)

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Electronics – I	**Course Code**	25PHY203DS04
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:

Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: To understand about the transistor amplifiers and their low-frequency response

CLO2: To understand the feedback process in amplifiers and the generation of signal through the oscillator

CLO3: Students would be able to realize the performance of operational amplifiers for various mathematical operations such as addition, subtraction, differentiation, integration etc

CLO4: To understand circuit analysis and implementation of operational amplifiers for various applications like comparators, A/D & D/A convertors, oscillators, etc

Unit 1:

Bipolar junction Transistor (BJT): Transistor action, Transistor biasing techniques and characteristics, Amplifying action, AC/DC load line, Transistor models and parameters, Equivalent circuits, Two-Port devices and Hybrid model, Transistor Hybrid model, Transistor h-parameters, Conversion for h-parameter for three Transistor Configurations, Analysis of a Transistor Amplifier Circuit for CE, CB, CC, Comparison of Transistor Amplifier Configurations, Linear Analysis of a Transistor Circuit, Miller's Theorem and its Dual, Cascading Transistor Amplifiers, classification of amplifiers, frequency response, RC coupled amplifier and its frequency response.

Unit 2:

Feedback-positive and negative feedback, Effect of negative feedback on gain, Non-linear distortion, input resistance, Frequency response, Voltage series and shunt feedback, Current series feedback. Transistor Power amplifiers: Class A, Class B, Class A push pull and Class B push pull amplifier

Principle of oscillations, condition for sustained oscillation, RF Oscillators using BJT, Hartley, Colpitts, Crystal Oscillator (Principle of working and frequency oscillation); AF Oscillators using BJT: Wein Bridge, Phase shift Oscillators. Multivibrator (Astable, Bistable, Monostable).

Unit 3:

Differential amplifier, CMRR, circuit configuration, emitter coupled supplied with constant current, transfer characteristics, block diagram of Op. Amp. Off-set currents and voltages, PSRR, Slew rate, universal balancing techniques, Inverting and non-inverting amplifier, basic applications- summing, scaling, current to voltage and voltage to current signal conversion, differential dc amplifier, voltage follower, bridge amplifier, AC-coupled amplifier. Integration, differentiation, analog computation, Butterworth active filters circuits.

Unit 4:

Comparators, AC/DC converters: Half wave & full wave rectifier, clamping circuits, Logarithmic amplifier, antilogarithmic amplifier, sample and hold circuits Digital to analog conversion –ladder and weighted resistor types, analog to digital conversion- counter type, regenerative comparator (Schmitt trigger), Oscillators using op-amp,: Feedback, Square wave generator, pulse generator, triangle wave generator. Sinusoidal oscillators: Phase shift, Colpitts, Hartley and Wein Bridge oscillator.

References:

1. Integrated Electronics by J. Millman and C.C. Halkias (Tata-McGraw Hill)
2. Fundamental of Electronics by J.D. Ryder (Prentice Hall Publication).
3. Electronics communication Systems by George Kennedy and Bernard George (McGraw Hill).
4. Linear Integrated Circuits by D. Roy Choudhury and Shail Jain (Wiley Eastern Ltd)
5. Solid State Electronic Devices by Ben G. Streetman ((Prentice Hall of India)
6. Electronic Devices and Circuit Theory by Robert L. Boylestad (Pearson).
7. Electronic Devices and Circuits, by David A. Bell (Oxford)

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Advanced Spectroscopy – I	**Course Code**	25PHY203DS05
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:

Examiner will set nine questions, and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, the examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: understand about the Raman effect and Raman spectra of diatomic molecules
CLO2: understand the electronic spectra and various electronic transitions in a molecule
CLO3: under about the infrared and Raman spectra of different molecules
CLO4: understand the generation of X-rays and its spectrum

Unit 1:

Raman effect - quantum theory - molecular polarizability pure rotational Raman spectra of diatomic molecules - vibration rotation Raman Spectrum of diatomic molecules. Intensity alternation in Raman spectra of diatomic molecules.

Unit 2:

Electronic spectra of diatomic molecules, Born Oppenheimer approximation - vibrational coarse structure of electronic bands -progression and sequences, intensity of electronic bands

- Frank Condon principle. Dissociation and pre- dissociation energy.

Unit 3:

Rotational fine structure of electronic bands. Experimental set up for Raman spectroscopy - application of IR and Raman spectroscopy in the structure determination of simple molecules.

Unit 4:

The origin of X-Rays, X-Ray emission spectra, Dependence of position of Emission lines on the atomic number, X-Ray emission (Doublet) spectra, Satellites, Continuous X-ray Emission, X-Ray Absorption spectra.

References:

1. Introduction to Atomic and Molecular Spectroscopy by V.K. Jain
2. Introduction to Atomic spectra by H.E. White
3. Fundamentals of molecular spectroscopy by C.B. Banwell
4. Spectroscopy Vol I and II by Walker and Straughen
5. Introduction to Molecular spectroscopy by G. M. Barrow
6. Spectra of diatomic molecules by Herzberg
7. Molecular spectroscopy by Jeanne. L. McHale
8. Molecular spectroscopy by J.M. Brown
9. Spectra of atoms and molecules by P. F. Bemath
10. Modern spectroscopy by J.M. Holias

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Computational Physics – I	**Course Code**	25PHY203DS06
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:

Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Students would acquire a vision for use of computer in research prospective.

CLO2: Students would be able to recognize the nature of a specific numerical problem and would develop the acumen for choosing an appropriate numerical technique to find its solution.

CLO3: Students would be able to design Fortran programs to solve numerical computationally

Unit 1:

Numerical Integration: Newton-cotes formulae: Trapezoidal rule, Simpson's 1/3 rule, error estimates in Trapezoidal rule and Simpson 1/3 rule using Richardson deferred limit approach; Gauss-Legendre quadrature method; Monte Carlo (mean sampling) method for single, double and triple integrals. Numerical Differentiation: Taylor Series method; Generalized numerical differentiation: truncation errors. Roots of Linear, Non-linear Algebraic and Transcendental equations: Newton-Raphson method; convergence of solutions. Curve Fitting: Principle of least square; Linear regression; Polynomial regression; Exponential and Geometric regression.

Unit 2:

Interpolation: Finite differences; Interpolation with equally spaced points; Gregory - Newton's Interpolation formula for forward and backward interpolation; Interpolation with unequally spaced points: Lagrangian interpolation, Solution of Simultaneous Linear Equations: Gaussian elimination method, Pivoting; Gauss- Jordan elimination method; Matrix inversion. Eigen values and Eigen vectors: Jacobi's method for symmetric matrix.

Unit 3:

Numerical Solution of First Order Differential Equations: First order Taylor Series method; Euler's method; Runge-Kutta methods; Predictor corrector method; Elementary ideas of solutions of partial differential equations, Numerical Solutions of Second Order Differential Equation: Initial and boundary value problems: shooting methods.

Unit 4:

Computer basics and operating system: Elementary information about digital computer principles; basic ideas of operating system, DOS and its use (using various commands of DOS); Compilers; interpreters; Directory structure; File operators.

Introduction to FORTRAN 77:Data types: Integer and Floating point arithmetic; Fortran variables; Real and Integer variables; Input and Output statements; Formats; Expressions; Built in functions; Executable and non-executable statements; Control statements; Go To statement; Arithmetic IF and logical IF statements; Flow charts; Truncation errors, Round off errors; Propagation of errors, Block IF statement; Do statement; Character DATA management; Arrays and subscripted variables; Subprograms: Function and SUBROUTINE; Double precision; Complex numbers; Common statement; New features of FORTRAN 90..

References:

1. Sastry: Introductory methods of Numerical Analysis.
2. Rajaraman: Numerical Analysis.
3. Ram Kumar: Programming with FORTRAN 77
4. Press, Teukolsky, Vellering and Flannery: numerical Recipes in FORTRAN.
5. Desai: FORTRAN programming and Numerical methods.
6. Dorn and McCracken: Numerical Methods with FORTRAN IV case studies.
7. Mathew: Numerical methods for Mathematics, Science and Engineering.
8. Jain, Iyngar and Jain: Numerical methods for Scientific and Engineering Computation"
9. Gould and Tobochnik An Introduction to Computer Simulation methods part I and Part II.
10. McCalla: Introduction to Numerical methods and FORTRAN programming.
11. Verma, Ahluwalia and Sharma: Computation Physics: An Introduction.

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Radiation Physics – I	**Course Code**	25PHY203DS07
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours
Note:			

Examiner will set nine questions, and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, the examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

After taking the course, students should be able to solve problems related to radiations and can explain

CLO1: radioactivity and uses of radioisotopes.

CLO2: radiation quantities and units.

CLO3: interaction of radiation with matter and neutrons

Unit 1:

The Nucleus and Radioactivity: Atomic structure, Nuclear mass, Binding energy, binding energy curve and its interpretation, Isotopes, Isotones, Isobars, Nuclear size, Radioactivity, Modes of radioactive disintegration, Nature and properties of radioactive radiations, The Laws of Radioactive decay, Half life time, Average life time, Radioactive growth and decay, Radioactive equilibrium (Ideal, Transient and Secular Equilibrium), Radioactive series, Radioactive branching, Radioactive dating (Determination of Age of Earth and Carbon Dating), Artificial radioactivity.

Unit 2:

Sources of Electromagnetic Radiations: Energetic Electron Sources (Beta, Internal Conversion, and Auger), Heavy Charged Particle Sources (Alpha and Fission Fragments); X-rays: Discovery, Production and Types of X-rays (characteristic and continuous) and Uses of X-rays; Cosmic rays: Discovery, Origin of Cosmic Rays, Nature of cosmic rays, Earth's Geometric effects (Altitude, Latitude and East-West Asymmetry), Primary and Secondary Cosmic Rays, Cosmic Ray Showers, soft and hard component, and on cosmic rays; Radon gas; Radioactive isotopes of lighter elements; Radiation quantities and units: Activity, KERMA, Exposure, Dose, Equivalent Dose, Effective Dose, Annual Limit on Intake (ALI), and Derived Air Concentration (DAC).

Unit 3:

Interaction of Radiation with Matter: Modes of interaction: ionization, excitation, elastic and inelastic scattering, Bremsstrahlung radiation, Cerenkov radiation, Concepts of specific ionization, Mean free path; Energy Loss by Heavy Charged Particles, Interaction of Light Charged Particles with matter, Range of Charged Particles, Interaction of Electromagnetic Radiations with matter: Photoelectric effect, Compton Scattering, and Pair production; Attenuation of Gamma Radiation: Linear and mass attenuation coefficient, Radiation length, Half-thickness.

Unit 4:

Neutron Physics and Particle Accelerators: Discovery of neutrons, Neutron sources, Neutron detectors: Principle and working of Slow neutron detectors, Intermediate neutrons detectors with examples, and Fast neutrons detectors; Tandem Accelerator: Principle, Construction, Working, Advantages, and Limitations; Linear Accelerator (LINAC): Principle, Construction, Working, Advantages, and Limitations; Cyclotrons: Principle, Construction, Working, Advantages, and Limitations; Betatron: Principle, Construction, Working, Advantages, and Limitations.

References:
1. Radiation Detection and Measurements by Glenn F. Knoll (Wiley India Pvt. Ltd.)
2. Nuclear Physics an Introduction by S. B. Patel (New Age International Publishers)
3. Introduction of Nuclear and Particle Physics by V. K. Mittal, R. C. Verma and S. C. Gupta (PHI Learning Pvt. Ltd. Delhi)
4. Nuclear and Particle Physics by S. L. Kakani and Shubhra Kakani
5. Radiation Oncology Physics: A handbook for teachers and students (International Atomic Energy Agency Vienna, 2005)
6. Practical knowledge for Handling Radioactive Sources by Dr. Claus Grupen
7. Introduction to Radiological Physics and Radiation Dosimetry by Frank Herbert Attlx

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Experimental Physics – I	**Course Code**	25PHY203DS08
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:
Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO1: Student would be able to differentiate between amorphous and crystalline materials using x-ray diffraction
CLO2: Student would be able to understand the working of x-ray diffractometer
CLO3: Student would be able to get familiarization with electron spectroscopy for surface analysis and Scanning probe microscopy
CLO4: Student would be able to understand nitty-gritty of electron microscopy techniques

Unit 1:
Properties of x-rays: Production of and detection of x-rays, Continues and characteristic x-rays, Diffraction of x-rays by crystalline materials: Bragg's law, Diffractometer and Debye Scherer for diffraction experiment and collection of diffraction data, Intensity of diffracted x-rays: scattering by an electron, an atom and a unit cell, structure factor, Six factors affecting the relative intensity of diffraction peaks, Indexing of powder diffraction data of cubic crystal system, determination of lattice parameters, strain and crystallite size from powder diffraction data(Scherer formula and Williamson's Hall Plot Method).

Unit 2:
Basic construction of scanning electron microscope and its various parts, Typical operating voltage, Signal generated during interaction of electron beam with material, resolution, magnification, Depth of field and focus, Imaging techniques in SEM: Secondary electron and back scattered electron, Chemical analysis using energy dispersive x-ray analysis (EDX).

Unit 3:
Comparison of optical microscope with transmission electron microscope, Basic construction

of transmission electron microscope and its various parts, typical operating voltages, Resolution and its relation with voltage, Magnification, Imaging modes in TEM: Bright field (BF), Dark field (DF) imaging, Selected area electron diffraction (SEAD) pattern of amorphous, polycrystalline materials, Indexing of SEAD pattern of simple cubic crystal system, Sample preparation for TEM: Powder and thin films.

Unit 4:

Basic principle of x-ray photoelectron spectroscopy and Auger electron spectroscopy, Instrumentation: Ultrahigh vacuum system, x-ray, electron and ion guns, Electron energy analysers, Characteristics of electron spectra, Photoelectron spectra, Auger electron spectra, Basic principle of atomic force microscopy, brief idea of set up, different modes of AFM (contact &tapping mode) and their importance, basic principle of scanning tunnelling microscopy, brief idea of set up/components, different modes of STM and its importance.

References:

1. Evans, C., Brundle, R., & Wilson. S. (1992). Encyclopaedia of Materials Characterization: Surfaces, Interfaces, Thin Films. Butterworth-Heinemann.
2. Leng, Y. (2013). Materials Characterization: Introduction to Microscopic and Spectroscopic Methods. Wiley-VCH.
3. Hummel, R.E. (2011). Electronic Properties of Materials. Springer.
4. Goldstein, J., Newbury, D.E., Joy, D.C., Lyman, C.E., Echlin, P., Lifshin, E., Sawyer, L., Michael, J.R. (2003). Scanning Electron Microscopy and X-Ray Microanalysis. Springer.
5. Cullity, B.D., & Stock, S.R. (2013). Elements of X-Ray Diffraction. Pearson.
6. Kaufmann, E.N. (2003). Characterization of Materials (Vol 1 & 2). John Wiley and Sons.
7. Carter, C.B., & Williams, D.B. (2016). Transmission Electron Microscopy Diffraction, Imaging, and Spectrometry (Carter, Barry, Williams, David B. Eds.)

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Practical: General Physics -III	**Course Code**	25PHY203DS09
Hours per Week	08	**Credits**	04
Maximum Marks	Internal=30 External=70 Total =100		

Note: Out of the list of experiments given below one experiment will be allotted through lottery method to each student on the day of examination to perform and then followed by Viva-voce.

Course Learning Outcomes (CLO):

CLO1: Student will be able to conduct experiments, as well as to analyze and interpret data.

CLO2: Student would be able to relate experiments with the theoretical aspects of the course.

CLO3: Student would be able to learn working with basic laser systems.

List of Experiments

1. Dispersion relation in a periodic electrical circuit: an analog of monatomic and diatomic lattice vibration
2. To determine the Lande- g factor of DPPH using ESR spectrometer.
3. To determine the wavelength of He-Ne laser light using an engraved scale as a diffraction grating.

4. Setting up a Fiber Optic Analog Link, Study of losses in Optical Fiber, Measurement of Propagation Loss and Measurement of Bending Loss.
5. Study of characteristics of fiber optic LED &detector, measurement of numerical aperture and study of frequency modulation &demodulation using fiber optic link.
6. To determine magneto resistance of a Bismuth crystal as a function of magnetic field
7. To study hysteresis in the electrical polarization of a TGS crystal and measure the Curie temperature.
8. Measurement of thickness of thin wire using He-Ne laser
9. Measurement and analysis of fluorescence spectrum of I2vapour
10. To study the thermo-luminescence of F-centers in Alkali halides crystals
11. Determination of e/m of electron by normal Zeeman effect using Febry Perot Etalon
12. G.M. Counters – characteristics, dead time and counting statistics

Note: Out of the list as above, a student has to perform atleast 08 (eight) practicals in the semester

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Practical: General Physics -IV	**Course Code**	24PHY203SE01
Hours per Week	08	**Credits**	04
Maximum Marks	Internal=30 External=70 Total =100		

Note: Out of the list of experiments given below one experiment will be allotted through lottery method to each student on the day of examination to perform and then followed by Viva-voce.

Course Learning Outcomes (CLO):

CLO1: Realize monoatomic and diatomic linear chain of atoms using passive electrical components and able to find the cut off frequency and understand dispersion relation as well as energy gap.

CLO2: Devise and understand various filter circuits and frequency response of push – pull amplifier.

CLO3: Determine the band gap of semiconductor materials, magnetic susceptibility of magnetic materials and dielectric constants of liquids.

CLO4: Comprehend fibre optic communication, different mechanism of signal loss and various type of pulse modulation.

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List of Experiments

1. Verification of Hartmann formula for prism spectrogram
2. Measurement of optical spectrum of an alkali atom
3. Measurement of Hall Coefficient of given semiconductor, Identification of charge carrier type and estimation of carrier concentration
4. To determine numerical aperture of an optical fiber and size of Lycopodium powder using semiconductor laser
5. To determine the specific heat of Nano Fluids
6. To study the characterization and phase transition using Nano fluid Interferometer

7. Study of Energy band gap and diffusion potential of PN junction
8. Study of NMR spectra using NMR spectrometer
9. Characteristics of Opto-electronic devices
10. Determination of thermal conductivity of given bar at different temperatures
11. Measurement of thermoelectric power.
12. Velocity of sound in air by CRO method.

Note: Out of the list as above, a student has to perform atleast 08 (eight) practical's in the semester

Semester-IV (Option – I)
Session: 2027-28

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Physics of Laser and Laser Applications	**Course Code**	25PHY204DS01
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:
Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO1: Student would be able to understand the diversity of laser designs and various applications.
CLO2: Understand the basic concepts of most of the commercially available lasers.
CLO3: Student will get the knowledge about the basic principles which form the basis of nonlinear optics.

Unit 1:
Laser characteristics: Spontaneous and Stimulated Emission, Absorption, Einstein Coefficients and their relationship, Laser Idea, threshold condition for laser oscillations, Pumping Schemes, Properties of Laser Beams: Monochromativity, Coherence, Directionality, Brightness, Radiation Trapping Superradiance, Superfluorescence, Amplified Spontaneous Emission, Non-radiative delay

Unit 2:
Pumping process: Optical pumping and pumping efficiency, Electrical pumping and pumping efficiency, Passive Optical Resonators, Types of Resonators, Stability Diagram, Different types of losses in optical Resonators. Rate Equations, Four-level Laser, Three-level Laser, Q Switching, Methods of Q-switching: Electro optical shutter, Kerr effect, Pockel effect in KDP crystal, mechanical shutter, Acousto - optic Q-switches, Mode locking, theory of mode locking, methods of mode locking (active & passive).

Unit 3:

Principle, working, characteristics and energy level diagram of various types of laser as Solid State Lasers; Ruby Laser, Neodymium laser, Gas lasers; Neutral Atom Gas Laser, Helium Neon Laser, Nitrogen Laser, Dye-Laser, Semiconductor Laser.

Unit 4:

Multiphoton photo-electric effects, Two-photon, Three-photon and Multiphoton Processes Raman Scattering, Stimulated Raman Effect, Introduction to Applications of Lasers: Physics, Chemistry, Biology, Medicine, Material, working, optical communication, Thermonuclear Fusion, Holography, Military etc.

References:

1. Introduction to Atomic and Molecular Spectroscopy by V.K. Jain
2. Yariv Optical Electronics
3. Demtroder: Laser Spectroscopy
4. Letekhov: Non-Linear Spectroscopy
5. Principles of Lasers by O. Svelto
6. Lasers and Non-linear Optics by B.B. Laud.

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Physics of Nanomaterials	**Course Code**	25PHY204DS02
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:

Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Students would be able to explain the properties of Nanomaterials/nanostructures.

CLO2: Students get enabled to analyse the density of states in various nanostructures and related effect on optical properties.

CLO3: Students get acquainted with important techniques for preparation of Nanomaterials/nanostructures.

CLO4: Understanding quantitatively, the experimental results of x-ray diffraction, photoluminescence and Raman spectra of Nanomaterials opens up avenues of future research.

Unit 1:

Free electron theory (qualitative idea) and its features, Idea of band structure: Kronig Penny model, Metals, insulators and semiconductors, Concept of effective mass, Derivation of density of states in 3D, 2D, 1D and 0D systems, Density of states in bands, Variation of density of states with energy, Variation of density of states and band gap energy with size of crystal, Electronic structure from Bulk to quantum dot, Excitons: Frenkel and Mott-Wannier excitons.

Unit 2:

Physics of reduced dimensional systems and devices: Quantum confinement, Electron confinement in one, two and three dimensional infinitely deep square well potentials, Various low dimensional systems: Quantum well structure; Idea of quantum well structure, Electron wave function and energy in quantum well structure (infinite well approximation), Density of states and optical absorption in quantum well, Quantum wires: Electron wave function and energy, Density of states, Quantum dots: Electron wave function and energy, Density of states, idea of hetero-junction LED, Quantum well laser and quantum dot laser, Coulomb blockade and Single electron transistor.

Unit 3:

Synthesis of Nanomaterials/Nanostructures: Bottom up and top down approaches for synthesis of nano materials, Synthesis of zero-dimensional nanostructures (Nanoparticles): Sol-Gel Process, Epitaxial core-shell nanoparticles, Ball milling, One-dimensional nanostructures (Nanowires, Nanorods, Nanotubes): Electrochemical deposition, Lithography, Two-dimensional nanostructures (Thin Films & Quantum wells): Molecular beam epitaxy (MBE), MOCVD, Cluster beam evaporation, Ion beam deposition, Chemical bath deposition technique.

Unit 4:

Characterization of Nanomaterials/Nanostructures: Effect of particle size and Strain on width of XRD peaks of nanomaterials, Determination of crystallite/particle size and strain in nanomaterials using Debye Scherer's formula and Williamson–Hall's plot, Transmission electron microscopy: Basic principle, Brief idea of set up, Sample preparation, Imaging modes (Dark & Bright Field), Photoluminescence (PL) spectroscopy: Basic principle and idea of instrumentation, Shift in PL peaks with particle Size, Determination of alloy composition in thin films of compound semiconductors, Estimation for width of quantum wells, Raman spectroscopy: Basic principle and idea of instrumentation, Variations in Raman spectra of nanomaterials with particle size, Study of Raman spectra of carbon nanotubes and graphene.

References:

1. Physics of Low Dimensional Semiconductors by John H. Davies (Cambridge Univ. Press).
2. Introduction to Nano-technology by Charles P. Poole & Jr. Frank J. Owens (Wiley Inter-science).
3. Quantum Mechanics for Nanostructures by Vladimir V. Mitin, Dmitry I. Sementsov & Nizami Z. Vagidov (Cambridge University Press).
4. Nanostructures & Nanomaterials: Synthesis, Properties & Applications by Guozhong Cao (Imperial College Press).
5. Introduction to Nano: Basics to Nanoscience and Nanotechnology by Amretashis Sengupta& Chandan Kumar Sarkar (Editor) [Springer].
6. Solid State Physics by A. J. Dekker (Macmillan).
7. Essentials in Nano-science and nanotechnology by Narendra Kumar, Sunita Kumbhat (Wiley)
8. Encyclopaedia of Materials Characterization: Surfaces, Interfaces, Thin Films by C. Richard Brundle and Charles A. Evans, Jr. (BUTTERWORTH-HEINEMANN).

Name of Program	M.Sc. Physics	**Program Code**	PHY2

Name of the Course	Condensed Matter Physics –II	**Course Code**	25PHY204DS03
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:

Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Explain the concepts different types of bonding in solids

CLO2: Understand some key and hot topics of condensed matter physics

CLO3: Have understanding of exotic solids and their important applications.

CLO4: Appreciate the few characterization techniques of nanomaterials

Unit 1:

Crystals of inert gases: Van der Waals-London interaction, Repulsive interaction, Equilibrium lattice constants, Cohesive energy, Ionic crystals, Electrostatic or Madelung energy, Evaluation of the Madelung constant, Covalent crystals, Hydrogen bonds, Atomic radii, Ionic crystal radii, Synthetic carbon allotropes, Fullerene, Carbon Nanotubes (CNTs): Classification, physical structure, Electronic, optical, mechanical properties of CNTs, CNTs based FETs, Graphene: Electronic structure of Graphene, Properties and few applications.

Unit 2:

Special topics in condensed mater: Integral and fractional quantum Hall effect: electron in a strong magnetic field, Landau levels and their degeneracy, simple explanation of IQHE; Metal- Insulator transitions: Mott- Hubbard and impurity induced; Landau theory of Fermi liquid, Mott variable range hopping, Bose- Einstein condensation.

Unit 3:

Glasses: Synthesis of glasses/preparation techniques/Methods of preparation, Glass transition, Structural theories of glass formation, Types of glasses, Radial distribution function, Density of states, Localized and extended states, Mobility edges, percolation, Optical properties of amorphous semiconductors, Polymers: Classification of polymers, Polymerization mechanism, thermal and optical

Unit 4:

X-ray diffractometer: Indexing of x-ray diffraction data of poly-crystalline materials, Determination of lattice parameters, crystallite size, Electron Diffraction: Basics of electron microscopes, electron beam specimen interaction, Scanning electron microscopy and Transmission electron microscopy, Imaging modes, Transport measurements: Two probe, four probes - Vander Pauw techniques, Scanning probe techniques: Principles of STM and AFM.

References:

1. Solid State Physics by A. J. Dekker (Macmillan)
2. Solid State Physics by Ashcroft & Mermin (Cengage Learning).
3. Introduction to Solid State Physics by Charles Kittel (Wiley).

4. Applied Solid State Physics by Rajnikant (Wiley).
5. Solid State Physics: Structure and Properties of Materials by M.A. Wahab (Wiley).
6. Elements of X-Ray Diffraction by B.D. Cullity (Pearson)
7. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods. By Leng, Y. (Wiley-VCH.)

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Electronics – II	**Course Code**	25PHY204DS04
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:
Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):
After successful completion of the course, the students will be able to
CLO1: express numbers, alphabets, special characters etc. in binary representation, perform mathematical operation in digitally and application of different codes.
CLO2: implement Boolean expression with basic gates and design circuits to achieve desired output.
CLO3: design basic building blocks of ICs for different electronics operations such as addition, subtraction, code generation, data register, counting etc. and develop various building blocks for ICs using MOSFET as MOS devices
CLO4: Understand the various types of modulation and microwave devices

Unit 1:
Binary numbers, Octal numbers, Hexadecimal numbers, Inter-conversions of numbers. Binary addition, subtraction, multiplication, division, Hexadecimal addition, subtraction, Octal addition, subtraction signed numbers, 1’s complement arithmetic, 2’s complement arithmetic, 9’s complement arithmetic, BCD code and arithmetic, Gray code, excess-3 code.
Positive and negative logic designations, OR gate, AND gate, NOT gate, NAND gate, NOR gate, XOR gate, Circuits and Boolean identities associated with gates, Boolean algebra-DeMorgans Laws, Sum of products and product of sums expressions, Minterm, Maxterm, K-maps, don’t care condition, deriving SOP and POS expressions from truth tables.

Unit 2:
Combinational Digital circuits: Binary adders: half adders & full adders, Decoders, Multiplexer, Demultiplexer, Encoders, ROM and its application (binary, BCD, Excess-3 Code, Gray Code & BCD to seven segment), Digital comparator, Parity checker and generator
Sequential Digital Circuits: 1-bit memory, Flip-Flops- RS, JK, master slave JK, T-type and D-type flip flops, Shift-register and applications, Asynchronous counters and Synchronous counters

Unit 3:

Metal oxide semiconductor field effect transistors, enhancement mode transistor, depletion mode transistor, p-channel and n-channel devices, MOS invertors- static inverter, dynamic inverter, two phase inverter, MOS NAND gates, NOR gates, complementary MOSFET technology, CMOS inverter, CMOS NOR gates and NAND gates, MOS shift register and RAM.

Unit 4:

Fundamentals of modulation, Frequency spectra in AM modulation, power in AM modulated class C amplifier, Efficiency modulation, frequency conversion, SSB system, Balanced modulation, filtering the signal for SSB, phase shift method, product detector, Pulse modulation, Microwave Devices: Resonant Cavity, Klystrons and Magnetron.

References:

1. Integrated Electronics by J. Millman and C.C. Halkias (Tata McGraw Hill).
2. Digital Electronics by William Gothmann (Prentice Hall of India)
3. Digital logic by J. M. Yarbrough (Thomson Publication).
4. Electronic Fundamentals and Applications by John D. Ryder (Prentice-Hall)
5. Foundation for Microwave Engineering by Robert E. Collin (Wiley)
6. Digital Principles and Applications by Donald P leach, Albert Paul Malvino (McGraw-Hill)

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Advanced Spectroscopy – II	**Course Code**	25PHY204DS05
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:

Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

After successful completion of the course, the students will be able to

CLO1: understand about the NMR and Mossbauer spectroscopy

CLO2: explain about the electron spin resonance and its spectra

CLO3: get understanding about the Laser spectroscopy and related applications

CLO4: Understand the time resolve spectroscopy and related phenomenon

Unit 1:

NMR: The principle of NMR, NMR spectrometer, Types of NMR, Types of nuclei viewed from the standpoint of NMR, High Resolution and Broad line NMR, Relaxation mechanisms, chemical shift; spin-spin coupling. Applications of NMR spectroscopy.

Mossbauer Spectroscopy: Mossbauer Spectrometer, Isomer nuclear transition, Resonance fluorescence, Mossbauer effect, Mossbauer nuclei, Isomer shift, quadrupole splitting, Magnetic hyperfine structure. Applications of Mossbauer spectroscopy.

Unit 2:

ESR spectrometer, substances which can be studied by ESR, Resonance condition. Description of ESR by Precession, Relaxation mechanisms, Features of ESR spectra (a) the g factor (b) Fine structure (c) hyperfine structure (d) ligand hyperfine structure. Applications of ESR

Unit 3:

Laser Spectroscopy, Detection Methods, Doppler-Limited Techniques, Time-Resolved Atomic and molecular Spectroscopy, Ultrafast Spectroscopy, High-Power Laser Experiments, High-Resolution Laser Spectroscopy, Cooling and Trapping of Ions and Atoms. Laser-Spectroscopic Applications:1 Diagnostics of Combustion Processes, Laser Remote Sensing of the Atmosphere, Laser-Induced Fluorescence and Raman Spectroscopy in Liquids and Solids, Laser-Induced Chemical Processes and Spectroscopic Aspects of Lasers in Medicine

Unit 4:

Time-resolved spectroscopy: Time-resolved fluorescence spectroscopy, Polarization in time-resolved fluorescence spectroscopy, Time-resolved fluorescence Stokes shift, Time-resolved four-wave mixing experiments, Third-order nonlinear response function, Pump-probe spectroscopy, Transient absorption spectra of excited electronic states, Time-resolved vibrational spectroscopy, Transient grating and photon echo experiments, Transient grating spectroscopy, Photon echo spectroscopy, Two-dimensional spectroscopy

References:

1. S K Dogra - Molecular Spectroscopy-McGraw-Hill Education (2012)
2. Svanberg S. - Atomic and Molecular Spectroscopy (2004, Springer)
3. Spectroscopy Vol I and II by Walker and Straughen
4. Introduction to Molecular spectroscopy by G. M. Barrow
5. Spectra of diatomic molecules by Herzberg
6. Molecular spectroscopy by Jeanne. L. McHale
7. Molecular spectroscopy by J.M. Brown
8. Spectra of atoms and molecules by P. F. Bemath
9. Modern spectroscopy by J.M. Holias

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Computational Physics – II	**Course Code**	25PHY204DS06
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:

Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Students would be able to understand framework of computer languages

CLO2: Students would be able to solve numerically various physical problems

CLO3: Students would gain the necessary basic knowledge of application of MATLAB for problem solving

Unit 1:

Random numbers: Random number generators, Mid-square methods, Multiplicative congruential method, mixed multiplicative congruential methods, modelling of 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, Un-damped motion, Damped motion, Driven and damped oscillator.

Unit 2:

Numerical solution of Radial Schrodinger equation for Hydrogen atom using Forth-order Runge-Kutta method (when Eigen value is given), Algorithms 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, Simulation of Planetary motion, Simulation of projectile motion

Unit 3:

MATLAB – I: Introduction, working with arrays, creating and printing plots, Interacting Computations: Matrices and Vectors, Matrices and Array Operations, built in functions, plotting simple graphs Programming in MATLAB: Script files, function files, Compiled files, p-code, variables, loops, branches, and control flow, Input/ Output, structures, cells

Unit 4:

MATLAB – II: Linear Algebra; solving a linear system, Gaussian elimination, finding eigenvalues and Eigen vectors, matrix factorization, Curve fitting and Interpolation; polynomial curve fitting, least square curve fitting, interpolation, Data analysis and statistics, Numerical integration; double integration, Ordinary differential equation; first order linear ODE, second order nonlinear ODE, tolerance, ODE suite

References:

1. Introduction to Numerical Analysis by F B Hildebrand (Tata McGraw Hill)
2. Fortran Programming and Numerical methods by R C Desai (Tata McGraw Hill).
3. Computer Applications in Physics by Suresh Chandra (Narosa Publishing House)
4. Numerical Recipes in Fortran 77 By William H. Press, Saul A Teukolsky, William T Vellerling and Brain P. Flannery (Cambridge University Press)
5. Introduction to Computation Physics by M L De Jong (Addison-Wesley).
6. Computational Physics an Introduction by R C Verma, P K Ahluwalia and K C Sharma (New Age International).
7. Computer Oriented Numerical Method by V Rajaraman (PHI).
8. An introduction to numerical analysis by K E Atkinson (John Wiley and Sons).
9. Getting Started with MATLAB by Rudra Pratap (Oxford University Press).
10. A concise introduction to MATLAB by William J Palm III (McGraw Hill).

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Radiation Physics – II	**Course Code**	25PHY204DS07
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of**	03 Hours

		Examinations	

Note:
Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):
After taking the course, students should be able to handle and resolve problems related to
CLO1: radiation detectors.
CLO2: Biological effects of radiation.
CLO3: radiation hazard

Unit 1:
Radiation Detectors-I: Principles of radiation detection, Gas-filled radiation detectors: Principle, Construction, Working and Concept of Average Energy Required for Creating Electron-Ion Pair (W-value); Ionization Chamber: Principle, Construction, Working, Advantages, and Limitations; Proportional Counter: Principle, Construction, Working, Advantages, and Limitations; G M Counter: Principle, Construction, Working, Advantages, and Limitations; Cloud Chamber: Principle, Construction, Working, Advantages, and Limitations; Bubble Chamber: Principle, Construction, Working, Advantages, and Limitations; Spark Chamber: Principle, Construction, Working, Advantages, and Limitations.

Unit 2:
Radiation Detectors-II: Scintillation Detectors: Principle, Scintillation Material/Crystal, Photomultiplier Tubes, Block Diagram, Advantages and Disadvantages; Semiconductor Detectors (Diffused Junction Detector, Silicon Surface Barrier Detector, Lithium drift Germanium detector, and Hyper Pure Germanium Detector): Principle, Construction, Working, Advantages, and Limitations; Thermo – Luminescent Dosimeters (TLD), Chemical detectors (Photographic Emulsions Films), Radiation Monitoring Instruments and Calibration check of radiation monitoring equipment.

Unit 3:
Biological Effects of Ionizing Radiation: Introduction, Cell Biology: Structure and function of living cell, cell division-mitosis, meiosis and differentiation, central dogma of molecular biology, genetic codes-DNA, RNA and Proteins; Effect of Radiation on Cell: inhibition of cell division, chromosome aberrations, genes mutation, and cell death; Biological effects of Radiation on Human: Somatic Effects (Early effect) and Stochastic effect (Late effect).

Unit 4:
Principles of Radiological Protection and Radiation Hazard: Justification of Practice, Optimization of Practice, and Dose Limitations; Internal Exposure, Dose Limit for (i) Radiation Workers (ii) Public, Occupational Exposure of Women, Apprentices and Students; Production of Radioisotopes and Labelled Compounds: Introduction, Separation of Isotopes, Production of labelled compounds, Specific Activity of labelled compounds, Storage, Quality, and Purity of Radio-labelled compounds; Internal Hazards and External Hazards; Evaluation and Control of Radiation Hazard; Radiation Emergency and Preparedness.

References:
1. Radiation Detection and Measurements by Glenn F. Knoll (Wiley India Pvt. Ltd.)

2. Nuclear Physics an Introduction by S. B. Patel (New Age International Publishers)
3. Introduction of Nuclear and Particle Physics by V. K. Mittal, R. C. Verma and S. C. Gupta (PHI Learning Pvt. Ltd. Delhi)
4. Nuclear and Particle Physics by S. L. Kakani and Shubhra Kakani
5. Radiation Oncology Physics: A handbook for teachers and students (International Atomic Energy Agency Vienna, 2005)
6. Practical knowledge for Handling Radioactive Sources by Dr. Claus Grupen
7. Introduction to Radiological Physics and Radiation Dosimetry by Frank Herbert Attlx
8. Radiation Biology: A handbook for teachers and students (International Atomic Energy Agency Vienna, 2010)

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Experimental Physics– II	**Course Code**	25PHY204DS08
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:

Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Students would be able to understand the working and application of absorption and emission spectroscopy for material characterization

CLO2: Student would be acquainted with IR and Raman spectroscopy

CLO3: Student would appreciate the electrical and dielectric properties of the materials and their data interpretation

CLO4: Students would get familiar with different tools for the measurement of thermal properties

Unit 1:

Basic principle and instrumentation of UV-Vis. spectroscopy, Optical absorption data, Optical absorption edge, Determination of optical band gap energy and type of optical transition from absorption data, Estimation of size of semiconducting nanoparticles using Brus equation, Basic principle and instrumentation of PL spectroscopy and its application in characterization of luminescent materials, Ellipsometry: Basic principle and instrumentation, determination of n, k and thickness of films.

Unit 2:

Electromagnetic Radiation and origin of molecular vibrations, Normal mode of molecular vibrations and number of normal vibration modes, Fourier transforms infrared spectroscopy: Infrared absorption and activity, Working principle and instrumentation, Examination techniques, transmittance, identifying characteristic bands, Raman Scattering: Basic principle, Raman activity and instrumentation, Analysis of Raman spectra.

Unit 3:

Differential scanning calorimetry and Differential thermal analysis: Thermal events, working principle, instrumentation and calibration of temperature, Determination of various characteristic temperatures from thermogram, Measurement of enthalpy change, Determination of specific heat, Thermogravimetry: Basic working principle and instrumentation, types and interpretation of thermogravimetric curves, study of stability of polymeric materials and determination of percentage crystallinity of polymer

Unit 4:

Measurement of resistivity using two, four probe and Vander paw methods: Solids samples and thin films, Hall Effect experiment, dielectric characterization using impedance Analyzer, Connection between different dielectric parameters, Review of magnetic materials, basic principle and brief idea about set-up of vibrating sample magnetometer (VSM) and SQUID magnetometer, magnetization vs. temperature profiling for zero field cooling (ZFC) and field cooling (FC), M-H hysteresis loops, AC magnetic susceptibility.

References:

1. Effect of replacement of Bi_2O_3 by Li_2O on structural, thermal, optical and other physical properties of zinc borate glasses, Manju Bala, Sunil Agrohiya, Sajjan Dahiya, Anil Ohlan, R Punia, AS Maan, Journal of Molecular Structure 1219 (2020) 128589.
2. Glass transition and crystallization kinetics of lithium modified zinc borate semiconducting glasses by non-isothermal method, Suman Pawaria, Jyoti Ahlawat, Preeti Sharma, Sajjan Dahiya, Anil Ohlan, R Punia, AS Maan, Ceramics International, 49(14) (2023) 23276-23286
3. Evans, C., Brundle, R., & Wilson. S. (1992). Encyclopaedia of Materials Characterization: Surfaces, Interfaces, Thin Films. Butterworth-Heinemann.
4. Leng, Y. (2013). Materials Characterization: Introduction to Microscopic and Spectroscopic Methods. Wiley-VCH.
5. Hummel, R.E. (2011). Electronic Properties of Materials. Springer.
6. Goldstein, J., Newbury, D.E., Joy, D.C., Lyman, C.E., Echlin, P., Lifshin, E., Sawyer, L., Michael, J.R. (2003). Scanning Electron Microscopy and X-Ray Microanalysis. Springer.
7. Cullity, B.D., & Stock, S.R. (2013). Elements of X-Ray Diffraction. Pearson.
8. Kaufmann, E.N. (2003). Characterization of Materials (Vol 1 & 2). John Wiley and Sons.

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Practical –Condensed Matter Physics	**Course Code**	25PHY204DS09
Hours per Week	08	**Credits**	04
Maximum Marks	Internal=30 External=70 Total =100		

Note: Out of the list of experiments given below one experiment will be allotted through lottery method to each student on the day of examination to perform and then followed by Viva-voce.

Course Learning Outcomes (CLO):

At the end of this laboratory course in Condensed Mater Physics, students would be able to:

CLO1: Characterize the semiconductor materials by determining resistivity, band gap, mobility, and carrier type.

CLO2: Understand phase transitions in ferroelectric materials and find the ferroelectric Curie temperature (Tc)

CLO3: Analyze the experimental data of powder diffraction in terms of indexing of peaks coming from different crystal planes and lattice parameters.

CLO4: Find the magnetic susceptibility and energy loss/volume/cycle in ferromagnetic materials.

List of Experiments

1. To study the B-H curve of a ferrite with temperature and hence find the ferromagnetic transition temperature of the material
2. Determination of dielectric constant of PZT material with temperature variation and hence find the Curie temperature (T_C)
3. To study the magnetoresistance of bismuth crystal
4. Measurement of magnetic susceptibility of paramagnetic materials using Gouy's method
5. To study thermo-luminescence of F-centres in alkali halide crystals
6. To simulate X-Ray Diffraction Experiment
7. Determination of particle size and lattice strain using Williamson's Halls Plot from x-ray diffraction data of a Nanomaterials
8. Indexing and determination of lattice parameter of a simple cubic crystal for a given x-ray diffraction data
9. To study hysteresis in the electrical polarization of a TGS crystal/PZT/BaTiO3with temperature and hence to find the Curie temperature (T_C)
10. Study of lead-tin phase diagram
11. Verification of Lambert Beer's law and determination of the concentration of an unknown solution by UV-Vis spectrophotometer
12. To measure the resistivity of an insulating material as a function of temperature and hence to find the activation energy for conduction

Note: Out of the list as above, a student has to perform atleast 08 (eight) practicals in the semester

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Practical: Electronics	**Course Code**	25PHY204DS10
Hours per Week	08	**Credits**	04
Maximum Marks	Internal=30 External=70 Total =100		

Note: Out of the list of experiments given below one experiment will be allotted through lottery method to each student on the day of examination to perform and then followed by Viva-voce.

Course Learning Outcomes (CLO):

CLO1: Students would be able to demonstrate the relation between the input and the corresponding digital output of various digital systems

CLO2: Designing basic building blocks for the ICs for different electronic functions like addition, subtraction, code generation, data register; counting etc. would help in realizing complex circuits.

CLO3: Students would be able to appreciate the effect of different types of modulation on the modulating signal.

CLO4: Students would be enabling for measurement of various digital circuits parameters and comparison of experimental outcomes with theoretical results.

List of Experiments

1. Pulse position/Pulse width Modulation/Demodulation
2. FSK Modulation Demodulation using Timer/PLL
3. PLL circuits and applications
4. BCD to Seven Segment display
5. To study digital to analog and analog to digital conversion (DAC to ADC) circuit.
6. Addition, subtraction, multiplication & division using 8085/8086.
7. To study various applications of op-amp
8. To study the digital comparator, 3-to-8-line Decoder and tri-state digital O/P circuits.
9. To study the binary module-6 and 8 decade counter and shift register.
10. Exp. Board on Timer (555) Applications
11. Study of frequency Multiplication using PLL
12. Study of Frequency Modulation and Demodulation
13. Study of Pulse Amplitude Modulations & Demodulation
14. Transfer characteristics of TTL inverter and TTL trigger inverter with two digital volt meter
15. Study of Module-N Counter using Programmable Counter IC 74190 with input Logics with LED display

Note: Out of the list as above, a student has to perform atleast 08 (eight) practicals in the semester

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Practical: Advanced Spectroscopy	**Course Code**	25PHY204DS11
Hours per Week	08	**Credits**	04
Maximum Marks	Internal=30 External=70 Total =100		

Note: Out of the list of experiments given below one experiment will be allotted through lottery method to each student on the day of examination to perform and then followed by Viva-voce.

Course Learning Outcomes (CLO):

CLO1: Students would be able to realize the different types of transitions in molecules and liquids

CO2 Students would understand dispersion relation and interferometers

CO3 Students would be able to analyse the spectra of alkali and transition metals.

List of Experiments

1. Jamin's interferometer – refractive index of air.
2. Measurement and analysis of electronic spectra of molecules and liquids.
3. Measurement and analysis of vibrational spectra of molecules and liquids.
4. Measurement and analysis of rotational spectra of molecules and liquids.
5. Measurement and analysis of absorption/transmission spectra of solids.
6. Study of line spectra on photographed plates/films and calculation of plate factor.
7. Verification of Hartman's dispersion formula.
8. Study of sharp and diffuse series of potassium atom and calculation of spin orbit interaction constant.
9. Michelson interferometer.
10. Analysis of ESR Spectra of transition metals.
11. Analysis of H-atom spectra in minerals.
12. LED & Laser Diode Characteristics Apparatus
    a) To Study I-V characteristics of LED and Diode Laser.
    b) To Study P-I characteristics of LED and Diode Laser.
13. To measure the numerical aperture (NA) of optical fiber
14. To determine the wavelength of He-Ne Laser light using an engraved scale as a diffraction grating.
15. Measurement of thickness of thin wire with laser
16. Determination of Lande's factor of DPPH using Electron - Spin resonance (E.S.R.) Spectrometer.

Note: Out of the list as above, a student has to perform atleast 08 (eight) practical's in the semester

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Practical: Computational Physics	**Course Code**	25PHY204SE01
Hours per Week	08	**Credits**	04
Maximum Marks	Internal=30 External=70 Total =100		

Note: Out of the list of experiments given below one experiment will be allotted through lottery method to each student on the day of examination to perform and then followed by Viva-voce.

Course Learning Outcomes (CLO):

CLO1: Students would develop an understanding of programming concepts.

CLO2: Students would learn the practical implementation of programming languages for carrying numerical calculations.

CLO3: Students would benefit from their enhanced computational skills in the context of higher studies in physics or business purposes as well.

List of Experiments

1. Numerical Integration
2. Least square fitting
3. Numerical solutions of equations (single variable)
4. Solution of H-atom problem
5. Solution of RL circuits
6. Numerical solution of simultaneous linear algebraic equations
7. Numerical solution of ordinary differential equation
8. Simulation of chaotic pendulum
9. Motion of Projectile thrown at an angle
10. Simulation of Planetary Motion
11. Charging and discharging of Capacitor
12. Solution of LCR circuit

Note: Out of the list as above, a student has to perform atleast 08 (eight) practicals in the semester

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Practical: Radiation Physics	**Course Code**	25PHY204SE02
Hours per Week	08	**Credits**	04
Maximum Marks	Internal=30 External=70 Total =100		

Note: Out of the list of experiments given below one experiment will be allotted through lottery method to each student on the day of examination to perform and then followed by Viva-voce.

Course Learning Outcomes (CLO):

CLO1: Students will get hand on experience on GM counter, Spark Counter, Scintillation counter

CLO2: Student will be able measure range of alpha, beta particles, attenuation coefficient

CLO3: Students will be aquatinted with different techniques of detection of nuclear radiations

CLO4: Students will be appreciating the interaction of nuclear radiation with mater

List of Experiments

1. Investigation of the plateau and optimal operating voltage of a Geiger-Muller counter
2. Investigation of statistical nature of counting rate
3. To determine the resolving time of a GM counter
4. To investigate the relationship between absorber materials (atomic number), absorption thickness and backscattering.
5. To verify the inverse square relationship between the distance and intensity of radiation.
6. To investigate the attenuation of radiation via the absorption of beta particles.
7. To determine the maximum energy of decay of a beta particle.
8. Measurement of range of α particle range in air using a spark counter
9. Study of the attenuation coefficients of the γ rays for Al, Fe and Pb using NaI scintillation counter
10. Measurement of γ ray energy of Cs-137 source using a NaI Scintillation detector

Note: Out of the list as above, a student has to perform atleast 08 (eight) practicals in the semester

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Practical: Experimental Physics	**Course Code**	25PHY204SE03
Hours per Week	08	**Credits**	04
Maximum Marks	Internal=30 External=70 Total =100		

Note: Out of the list of experiments given below one experiment will be allotted through lottery method to each student on the day of examination to perform and then followed by Viva-voce.

Course Learning Outcomes (CLO):

CLO1: Student would be able to record and interpret the optical absorption data

CLO2: Student would be able to understand the working of x-ray diffractometer and analysis of x-ray diffraction data

CLO3: Student would be able to measure dielectric parameters and their interpretation

CLO4: Student would be able to analyze AFM, SEM and TEM Images.

List of Experiments

1. To record the optical absorption data of a solid transparent sample such as glass and to
   a) find the optical band gap (E_g) energy from cut-off wavelength
   b) find the optical band gap energy (E_g) using Tauc's relation
   c) type of optical transitions
   d) Urbach's energy
2. To record the optical absorption spectrum of semiconducting nanoparticles and hence to estimate the size of nanoparticles using Brus equation
3. To record x-ray diffraction data of a simple cubic crystalline material and to find the lattice parameters using manual indexing method

4. Recording of x-ray diffraction data of nanomaterials and hence to find the crystallite size and using Scherer equation
5. Measurement of capacitance and dielectric loss of a ferroelectric material using Impedance analyzer/ LCR meter
   a) at a fixed frequency to find the ferroelectric transition temperature
   b) at different temperature as function of frequency to find different dielectric parameters from measured values of C and D
6. To obtain DSC thermogram of a glass sample find the glass transition, crystallization, melting temperature
7. To obtain FTIR data of sample and assignment of different functional group present
8. Analysis of Scanning electron micrograph of a material using ImageJ software
9. Analysis of Transmission electron micrograph (Bright and Dark Field images) of a material using ImageJ software
10. Indexing of selected area electron diffraction (SAED) pattern of a simple cubic crystalline material
11. Measurement of PL spectra of luminescent materials and to find photoluminescence quantum efficiency (PLQE)
12. To study the transient photo response of a UV detector in plane and sandwich geometry and also draw I-V characteristics of photodetector in absence and presence of UV light

Note: Out of the list as above, a student has to perform atleast 08 (eight) practicals in the semester

Semester-III (Option – II)
Session: 2027-28

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Nuclear and Particle Physics	**Course Code**	25PHY203DS01
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:
Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO1: Students would be able to realize the nature of nuclear force and nuclear reactions.
CLO2: Students would be able to understand the structure of the nucleus and would be able to find out the spin, parity, magnetic moments etc. of different nuclei.
CLO3: Students would be able to understand different nuclear decays.
CLO4: Students would gain basic knowledge about Elementary Particles and their interactions.

Unit 1:

Two nucleon problem: Common potentials used for calculation of nuclear forces viz. Wigner, Majorana, Bartlett and Heisenberg potentials, The ground state of deuteron, Square well solution for the deuteron, Qualitative features of Nucleon – nucleon scattering, Effective range theory in n – p scattering and Significance of sign of scattering length; Meson theory of nuclear force (Qualitative discussion);Types of nuclear reactions: compound and direct nuclear reactions, Reaction cross – section, Reaction cross-section in terms of partial wave treatment, Balance of mass and energy in nuclear reactions, Q equation and its solution.

Unit 2:

Liquid drop model: Similarities between liquid drop and nucleus, Semi-empirical mass formula, Mass Parabolas (Prediction of stability against β-decay for members of an Isobaric family), Stability limits against spontaneous fission, Merits and limitations of Liquid drop model; Shell model: Experiment evidences for shell effect, Magic numbers, Main assumptions of the single particle shell model, Spin-orbit coupling in single particle shell model, Estimation of spin, parities and magnetic moments of nuclei by single particle shell model.

Unit 3:

Nuclear Decays: Alpha (α) decay, α- disintegration energy, Range of α-particles, Range – energy relationship for α-particles and Geiger – Nuttall law; Beta decay, Pauli's neutrino hypothesis, Fermi theory of beta decay, Curie plot, selection rules for beta decay, Fermi and Gamow-Teller Transitions, Detection and properties of neutrino; Gamma decay, Multipole transitions in nuclei, Angular momentum and parity selection rules; Internal conversion, Nuclear isomerism.

Unit 4:

Elementary Particle Physics: Classifications of elementary particles: fermions and bosons, particles and antiparticles; Fundamental interactions in nature; Type of interaction between elementary particles: Symmetry and conservation laws; Classification of hadrons: Strangeness, Hypercharge, Gelleman - Nishijima formula, Elementary ideas of CP and CPT invariance; Quark model, Baryon Octet, Meson Octet, Baryon Decuplet, Gell-Mann-Okubo formula for octet and decuplet, the necessity of introducing the colour quantum number, SU (2) and SU (3) multiples (qualitative only).

References:

1. Nuclear Physics Theory and Experiment by R.R. Roy and B.P. Nigam (New Age International (P) Limited, Publishers)
2. Nuclear Physics- An introduction by S B Patel (New Age International (P) Limited, Publishers)
3. Concepts of Modern Physics by Arthur Beiser, S Mahajan, and S Rai Choudhury (Mc Graw Hill Education)
4. Introductory Nuclear Physics by Kenneth S. Krane (Wiley, New York)
5. Introductory Nuclear Physics by Y.R. Waghmare (Oxford – IBH, Bombay)
6. Nuclear Physics, 2nd addition by Kapaln (Narosa, Madras)
7. Introduction to Nuclear Physics by F.A. Enge (Addison-Wesley)
8. Nucleon Interaction by G.E. Brown and A.D. Jackson (North-Holland, Amsterdam)
9. Nuclear and Particle Physics by S L Kakani and Shubhra Kakani (Viva Books)
10. Introduction to High Energy Physics by P.H. Perkins (Addison-Wesley, London, 1982)

11. Introduction to Elementary Particles by D. Griffiths (Harper and Row, New York, 1987).

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Electrodynamics and Wave propagation	**Course Code**	25PHY203DS02
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:

Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Students would be able to formulate and solve electrodynamic problems in relativistic covariant form in four-dimensional space.

CLO2: Students would gain knowledge about electrostatic and magnetic fields produced by static and moving charges in a variety of simple configurations.

CLO3: Would be able to analyze the basics of theory of transmission lines and waveguides.

Unit 1:

Review of four-vector and Lorentz transformation in four-dimensional space; Conservation of charge and four current density; Electromagnetic field tensor in four dimensions and Maxwell's equations; Lorentz invariants of electromagnetic fields; Dual field tensor; Transformation of electric and magnetic field vectors; Covariance of force equation.

Unit 2:

Radiating systems: Field and radiation of a localized source; Oscillating electric dipole; Centre fed linear antenna; Lienard-Wiechert potential; Electric and magnetic fields due to a uniformly moving charge and accelerated charge; Linear and circular acceleration and angular distribution of power radiated.

Unit 3:

Radiative reaction force; Scattering and absorption of radiation; Thompson scattering and Rayleigh scattering; Normal and anomalous dispersion; Ionosphere; Propagation of electromagnetic wave through ionosphere; Reflection of electromagnetic waves by ionosphere; Motion of charged particles in uniform E and B fields; Time varying fields.

Unit 4:

Fields at the surface of and within a conductor; Wave guides; Modes in a rectangular waveguide; Attenuation in waveguides; Dielectric waveguides; Circuit representation of parallel plate transmission lines; Transmission line equations and their solutions; Characteristic impedance and propagation coefficient; Low loss radio frequency and UHF transmission lines.

References:

1. Classical Electrodynamics by J.D. Jackson

2. Introduction to Electrodynamics by D.J. Griffiths
3. Electromagnetic by B.B. Laud
4. Classical Electricity and Magnetism by Panofsky and Phillips
5. Fundamentals of Electromagnetics by M.A. Wazed Miah

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Physics of Laser and Laser Applications	**Course Code**	25PHY204DS01
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:
Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Student would be able to understand the diversity of laser designs and various applications.

CLO2: Understand the basic concepts of most of the commercially available lasers.

CLO3: Student will get the knowledge about the basic principles which form the basis of nonlinear optics.

Unit 1:
Laser characteristics: Spontaneous and Stimulated Emission, Absorption, Einstein Coefficients and their relationship, Laser Idea, threshold condition for laser oscillations, Pumping Schemes, Properties of Laser Beams: Monochromativity, Coherence, Directionality, Brightness, Radiation Trapping Superradiance, Superfluorescence, Amplified Spontaneous Emission, Non-radiative delay

Unit 2:
Pumping process: Optical pumping and pumping efficiency, Electrical pumping and pumping efficiency, Passive Optical Resonators, Types of Resonators, Stability Diagram, Different types of losses in optical Resonators. Rate Equations, Four-level Laser, Three-level Laser, Q Switching, Methods of Q-switching: Electro optical shutter, Kerr effect, Pockel effect in KDP crystal, mechanical shutter, Acousto - optic Q-switches, Mode locking, theory of mode locking, methods of mode locking (active & passive).

Unit 3:
Principle, working, characteristics and energy level diagram of various types of laser as Solid State Lasers; Ruby Laser, Neodymium laser, Gas lasers; Neutral Atom Gas Laser, Helium Neon Laser, Nitrogen Laser, Dye-Laser, Semiconductor Laser.

Unit 4:
Multiphoton photo-electric effects, Two-photon, Three-photon and Multiphoton Processes Raman Scattering, Stimulated Raman Effect, Introduction to Applications of Lasers: Physics, Chemistry, Biology, Medicine, Material, working, optical communication, Thermonuclear

Fusion, Holography, Military etc.

References:

1. Introduction to Atomic and Molecular Spectroscopy by V.K. Jain
2. Yariv Optical Electronics
3. Demtroder: Laser Spectroscopy
4. Letekhov: Non-Linear Spectroscopy
5. Principles of Lasers by O. Svelto
6. Lasers and Non-linear Optics by B.B. Laud.

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Physics of Nanomaterials	**Course Code**	25PHY204DS02
Hours per Week	04(3+1)	**Credits**	04
Maximum Marks	100(30+70)	**Time of Examinations**	03 Hours

Note:

Examiner will set nine questions of fourteen marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Students would be able to explain the properties of Nanomaterials/nanostructures.

CLO2: Students get enabled to analyze the density of states in various nanostructures and related effect on optical properties.

CLO3: Students get acquainted with important techniques for preparation of Nanomaterials/nanostructures.

CLO4: Understanding quantitatively, the experimental results of x-ray diffraction, photoluminescence and Raman spectra of Nanomaterials opens up avenues of future research.

Unit 1:

Free electron theory (qualitative idea) and its features, Idea of band structure: Kronig Penny model, Metals, insulators and semiconductors, Concept of effective mass, Derivation of density of states in 3D, 2D, 1D and 0D systems, Density of states in bands, Variation of density of states with energy, Variation of density of states and band gap energy with size of crystal, Electronic structure from Bulk to quantum dot, Excitons: Frenkel and Mott-Wannier excitons.

Unit 2:

Physics of reduced dimensional systems and devices: Quantum confinement, Electron confinement in one, two and three dimensional infinitely deep square well potentials, Various low dimensional systems: Quantum well structure; Idea of quantum well structure, Electron wave function and energy in quantum well structure (infinite well approximation), Density of states and optical absorption in quantum well, Quantum wires: Electron wave function and energy, Density of states, Quantum dots: Electron wave function and energy, Density of states, idea of hetero-junction LED, Quantum well laser and quantum dot laser, Coulomb blockade and Single electron transistor.

Unit 3:

Synthesis of Nanomaterials/Nanostructures: Bottom up and top down approaches for synthesis of nano materials, Synthesis of zero-dimensional nanostructures (Nanoparticles): Sol-Gel Process, Epitaxial core-shell nanoparticles, Ball milling, One-dimensional nanostructures (Nanowires, Nanorods, Nanotubes): Electrochemical deposition, Lithography, Two-dimensional nanostructures (Thin Films & Quantum wells): Molecular beam epitaxy (MBE), MOCVD, Cluster beam evaporation, Ion beam deposition, Chemical bath deposition technique.

Unit 4:

Characterization of Nanomaterials/Nanostructures: Effect of particle size and Strain on width of XRD peaks of nanomaterials, Determination of crystallite/particle size and strain in nanomaterials using Debye Scherer's formula and Williamson–Hall's plot, Transmission electron microscopy: Basic principle, Brief idea of set up, Sample preparation, Imaging modes (Dark & Bright Field), Photoluminescence (PL) spectroscopy: Basic principle and idea of instrumentation, Shift in PL peaks with particle Size, Determination of alloy composition in thin films of compound semiconductors, Estimation for width of quantum wells, Raman spectroscopy: Basic principle and idea of instrumentation, Variations in Raman spectra of nanomaterials with particle size, Study of Raman spectra of carbon nanotubes and graphene.

References:

1. Physics of Low Dimensional Semiconductors by John H. Davies (Cambridge Univ. Press).
2. Introduction to Nanotechnology by Charles P. Poole & Jr. Frank J. Owens (Wiley Inter-science).
3. Quantum Mechanics for Nanostructures by Vladimir V. Mitin, Dmitry I. Sementsov & Nizami Z. Vagidov (Cambridge University Press).
4. Nanostructures & Nanomaterials: Synthesis, Properties & Applications by Guozhong Cao (Imperial College Press).
5. Introduction to Nano: Basics to Nanoscience and Nanotechnology by Amretashis Sengupta& Chandan Kumar Sarkar (Editor) [Springer].
6. Solid State Physics by A. J. Dekker (Macmillan).
7. Essentials in Nano-science and nanotechnology by Narendra Kumar, Sunita Kumbhat (Wiley)
8. Encyclopaedia of Materials Characterization: Surfaces, Interfaces, Thin Films by C. Richard Brundle and Charles A. Evans, Jr. (BUTTERWORTH-HEINEMANN).

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Practical: General Physics -III	**Course Code**	25PHY203DS09
Hours per Week	08	**Credits**	04
Maximum Marks	Internal=30 External=70 Total =100		

Note: Out of the list of experiments given below one experiment will be allotted through lottery method to each student on the day of examination to perform and then followed by Viva-voce.

Course Learning Outcomes (CLO):

CLO1: Student will be able to conduct experiments, as well as to analyze and interpret data.

CLO2: Student would be able to relate experiments with the theoretical aspects of the course.

CLO3: Student would be able to learn working with basic laser systems.

List of Experiments

1. Dispersion relation in a periodic electrical circuit: an analog of monatomic and diatomic lattice vibration
2. To determine the Lande- g factor of DPPH using ESR spectrometer.
3. To determine the wavelength of He-Ne laser light using an engraved scale as a diffraction grating.
4. Setting up a Fiber Optic Analog Link, Study of losses in Optical Fiber, Measurement of Propagation Loss and Measurement of Bending Loss.
5. Study of characteristics of fiber optic LED &detector, measurement of numerical aperture and study of frequency modulation &demodulation using fiber optic link.
6. To determine magneto resistance of a Bismuth crystal as a function of magnetic field
7. To study hysteresis in the electrical polarization of a TGS crystal and measure the Curie temperature.
8. Measurement of thickness of thin wire using He-Ne laser
9. Measurement and analysis of fluorescence spectrum of I2vapour
10. To study the thermo-luminescence of F-centres in Alkali halides crystals
11. Determination of e/m of electron by normal Zeeman effect using Febry Perot Etalon
12. G.M. Counters – characteristics, dead time and counting statistics

Note: Out of the list as above, a student has to perform atleast 08 (eight) practicals in the semester

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Practical: General Physics -IV	**Course Code**	25PHY203SE01
Hours per Week	08	**Credits**	04
Maximum Marks	Internal=30 External=70 Total =100		

Note: Out of the list of experiments given below one experiment will be allotted through lottery method to each student on the day of examination to perform and then followed by Viva-voce.

Course Learning Outcomes (CLO):

CLO1: Realize monoatomic and diatomic linear chain of atoms using passive electrical components and able to find the cut off frequency and understand dispersion relation as well as energy gap.

CLO2: Devise and understand various filter circuits and frequency response of push – pull amplifier.

CLO3: Determine the band gap of semiconductor materials, magnetic susceptibility of magnetic materials and dielectric constants of liquids.

CLO4: Comprehend fiber optic communication, different mechanism of signal loss and various type of pulse modulation.

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List of Experiments

1. Verification of Hartmann formula for prism spectrogram
2. Measurement of optical spectrum of an alkali atom
3. Measurement of Hall Coefficient of given semiconductor, Identification of charge carrier type and estimation of carrier concentration
4. To determine numerical aperture of an optical fibre and size of Lycopodium powder using semiconductor laser
5. To determine the specific heat of Nano Fluids
6. To study the characterization and phase transition using Nano fluid Interferometer
7. Study of Energy band gap and diffusion potential of PN junction
8. Study of NMR spectra using NMR spectrometer
9. Characteristics of Opto-electronic devices
10. Determination of thermal conductivity of given bar at different temperatures
11. Measurement of thermoelectric power.
12. Velocity of sound in air by CRO method.

Note: Out of the list as above, a student has to perform atleast 08 (eight) practical's in the semester

Semester-IV (Option – II)
Session: 2027-28

Name of Program	M.Sc. Physics	**Program Code**	PHY2
Name of the Course	Characterization Techniques	**Course Code**	25PHY204SE04
Hours per Week	04	**Credits**	04
Maximum Marks	Theory :50(15+35) Practical: 50	**Time of Examinations**	03 Hours

Note:

Examiner will set nine questions of seven marks each and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Exposure to spectroscopic techniques enables the scholars a great deal in material science to understand the complexities & decide for end applications.

CLO2: The various techniques such as VSM, Hysterias loops, electrical characterization help in applied aspects of research.

CLO3: Characterization techniques / setups including XRD, DSC, AFM, STM etc are extremely important in basic as well as applied research.

Unit 1:

Basic principle and instrumentation of UV-Vis. spectroscopy, photoluminescence spectroscopy, and ellipsometry, determination of optical band gap and other optical parameters, basic principle of FTIR and Raman spectroscopy, brief idea of set up (includes source, detector, operating conditions and excitation wavelength choice), deconvolution of the peaks, analysis of the spectra based on peak position, FWHM of the vibrational modes. (case study of each technique)

Unit 2:

Review of magnetic materials, basic principle and brief idea about set-up of vibrating sample magnetometer (VSM) and SQUID magnetometer, magnetization vs. temperature profiling for zero field cooling (ZFC) and field cooling (FC), M-H hysteresis loops, AC magnetic susceptibility, electrical characterization: two probe, four-probe and van-der pauw method for resistivity measurements, Hall effect experiment, dielectric characterization using impedance Analyzer, electrochemical techniques: cyclic voltammetry(case study of each technique)

Unit 3:

Brief review of crystal structure, X-ray diffraction methods, modern X-ray diffractometer, indexing of X-ray diffraction peaks, data analysis and interpretation, crystallite size and strain measurement in nanomaterials, basic principle of scanning electron microscopy, energy dispersive X-ray analysis, basic principle of transmission electron microscopy, brief idea of set up, sample preparation, imaging modes: bright field imaging, dark field imaging, selected area electron diffraction etc. (case study of each technique)

Unit 4:

Basic principle of atomic force microscopy, brief idea of set up, different modes of AFM (contact &tapping mode) and their importance, basic principle of scanning tunnelling microscopy, brief idea of set up/components, different modes of STM and its importance, TGA and DSC/DTA: principle, practical aspects, experimental variables, data analysis and interpretation (case study of each technique).

References:

1. Transmission Electron Microscopy: Diffraction, Imaging, and Spectrometry by C. Barry Carter · David B. Williams (Springer).
2. Elements of X-ray Diffraction by B. D. Cullity (Pearson).
3. Scanning Electron Microscopy and X-Ray Microanalysis by Joseph I. Goldstein (Kluwer Academic).
4. Electronic Properties of Materials by Rolf E. Hummel (Springer)
5. Characterization of Materials, (Volumes 1 & 2) Elton N. Kaufmann, John Wiley and Sons Publication
6. Materials Characterization, Introduction to Microscopic and Spectroscopic Methods by Yang Leng, John Wiley & Sons (Asia) Pvt Ltd
7. Encyclopaedia of Materials Characterization: Surfaces, Interfaces, Thin Films by C. Richard Brundle and Charles A. Evans, Jr. (BUTTERWORTH-HEINEMANN).

Note: Out of the list of experiments given below one experiment will be allotted through lottery method to each student on the day of examination to perform and then followed by Viva-voce.

List of Experiments

1. To record the optical absorption data of a solid transparent sample such as glass and to
   a) find the optical band gap (E_g) energy from cut-off wavelength
   b) find the optical band gap energy (E_g) using Tauc's relation
   c) type of optical transitions

d) Urbach's energy

2. To record the optical absorption spectrum of semiconducting nanoparticles and hence to estimate the size of nanoparticles using Brus equation
3. To record x-ray diffraction data of a simple cubic crystalline material and to find the lattice parameters using manual indexing method
4. Recording of x-ray diffraction data of nanomaterials and hence to find the crystallite size and using Scherer equation
5. Measurement of capacitance and dielectric loss of a ferroelectric material using Impedance analyzer/ LCR meter
   a) at a fixed frequency to find the ferroelectric transition temperature
   b) at different temperature as function of frequency to find different dielectric parameters from measured values of C and D
6. To obtain DSC thermogram of a glass sample find the glass transition, crystallization, melting temperature
7. Analysis of Scanning electron micrograph of a material using ImageJ software
8. Analysis of Transmission electron micrograph (Bright and Dark Field images) of a material using ImageJ software
9. Indexing of selected area electron diffraction (SAED) pattern of a simple cubic crystalline material

Note: Out of the list as above, a student has to perform atleast 08 (eight) practicals in the semester

M.Sc. Physics Semester IV

Project/Dissertation (25PHY204PD01)

Max Marks: 500

Rules

Distribution/allotment of students to be done at the Department level. Dissertation work will be based on a research work or completion of experimental techniques or compilation of thematic research studies. The structure of the Dissertation could be as follows:

Sr. No	Structure of Dissertation
1.	Acknowledgement
2.	Certificate of supervisor
3.	Introduction
4.	Review of Literature
5.	Materials & Methods / Theoretical Background
6.	Results and Discussion
7.	Summary
8.	References

Last date of dissertation submission, fee, plagiarism policy, etc. will be as per university guidelines. Evaluation of Project work will be performed by an external examiner (From the panel approved by PGBOS) and an internal examiner (Supervisor/Guide). The bifurcation of the marks will be as follows:

Examiner	Components	Marks
External	Dissertation	150
	Presentation	100
	Viva-voce	100
Internal	Dissertation & overall assessment	150
Total Marks		**500**

Three hard bound copies and one soft bound copy of the dissertation will be prepared (one copy for the departmental record, one copy for the guide/supervisor, one copy for the student and a soft bound copy for the library. Any patent /IPR based on experimental work will be in the name of student/s and guide/supervisor as an inventor. A publication based on dissertation work should be with the consent of guide only.