PG Program in Physics as per NEP-2020

SEMESTER - I **Core Courses** **Total Program Credits: 80 (Eighty)**

S. No	Course Code	Theory Courses	L	T	P	Credits
1.	PSPHY 101	Quantum Mechanics	3	1	0	4
2.	PSPHY 102	Classical Electrodynamics	3	1	0	4
3.	PSPHY 103	Statistical Mechanics	3	1	0	4
4.	PSPHY 104	Condensed Matter Physics	3	1	0	4
5	PSPHY 105	Mathematical Physics and Classical Mechanics/ Data Science*/Any other Engineering Course*	3	1	0	4
		Laboratory Courses				
6.	PSPHY LB1	Laboratory for Solid State Materials	0	0	4	2
7.	PSPHY LB2	Laboratory for Computational Physics	0	0	4	2
	Total					**24**

SEMESTER – II **Core Courses**

S. No	Course Code	Theory Courses	L	T	P	Credit
1.	PSPHY 201	Atomic & Molecular Physics	3	1	0	4
2.	PSPHY 202	Applied Optics and Photonics	3	1	0	4
3.	PSPHY 203	Nuclear and Particle Physics/ *Artificial Intelligence	3	1	0	4
4.	PSPHY 204	Semiconductor Physics and Devices	3	1	0	4
5.	PSPHY 205	Low Dimensional Physics	3	1	0	4
		Laboratory Courses				
6.	PSPHY LB3	Laboratory for Optics and Photonics	0	0	4	2
7.	PSPHY LB4	Laboratory for Synthesis of Nanomaterials	0	0	4	2
	Total					**24**

SEMESTER – III Students have to choose 4 electives (Either from below or from list overleaf)

S. No	Course Code	Courses - Department Elective Courses	L	T	P	Credits
1.	PSPHY EL1	Nanoscience and Nanotechnology	3	0	0	3
2.	PSPHY EL2	Renewable Sources of Energy	3	0	0	3
3.	PSPHY EL3	Quantum Computation and Information	3	0	0	3
4.	PSPHY EL4	Atmospheric and Environmental Physics	3	0	0	3
5.	PSPHY EL5	Quantum Logic and Simulations	3	0	0	3
6.	PSPHY EL6	Defects in Solid State Physics	3	0	0	3
7.	PSPHY EL7	Photovoltaic Systems	3	0	0	3
		Laboratory Core Courses				
9.	PSPHY LB5	Laboratory for Characterization of Materials	0	0	4	2
10.	PSPHY LB6	Electronics Tinkering Laboratory.	0	0	4	2
	Total					**16**

SEMESTER – IV

S.	Course Code	Courses	L	T	P	Credits
1.	PSPHY PR1	Research Based Project (Full Semester)	0	0	32	**16**
	Total					**16**

(A) List of Departmental Electives for M.sc/ Pre Ph.D.-Course Work/Electives for other Departments (OPEN)

S. No.	Course Code	Courses	L	T	P	Credits
1.	**PSPHY ELC**	**Research Methodology (Core Course)**	**3**	**0**	**0**	**3**
2.	PSPHY ELR1	General Theory of Relativity and Cosmology	3	0	0	3
3.	PSPHY ELR2	Nano-Biomaterials, Biosensors and Applications	3	0	0	3
4.	PSPHY ELR3	Superconductivity and Low Temperature Physics	3	0	0	3
5.	PSPHY ELR4	Nano-Fabrication of Materials	3	0	0	3
6.	PSPHY ELR5	Principles of Lasers and Fiber Optics	3	0	0	3
7.	PSPHY ELR6	Functional Materials and Applications	3	0	0	3
8.	PSPHY ELR7	Quantum Field Theory	3	0	0	3
9.	PSPHY ELR8	Python Programming and Introduction to Data Science	3	0	0	3
10.	PSPHY ELR9	Spin-electronics and applications	3	0	0	3
11	PSPHY ELR10	Advanced Condensed Matter Physics	3	0	0	3
12.	PSPHY ELR11	Characterizations Techniques of Materials	3	0	0	3
13.	PSPHY ELR12	Group Theory for Physicists.	3	0	0	3
14.	PSPHY ELR13	Machine Learning/Artificial intelligence	3	0	0	3
15.	PSPHY ELR14	Medical Physics	3	0	0	3

Physics Department is First to adopt Curriculum as per NEP 2020

SEMESTER - I

Core Courses

S. No	Course Code	Theory Courses	L	T	P	Credits
1.	PSPHY 101	Quantum Mechanics	3	1	0	4
2.	PSPHY 102	Classical Electrodynamics	3	1	0	4
3.	PSPHY 103	Statistical Mechanics	3	1	0	4
4.	PSPHY 104	Condensed Matter Physics	3	1	0	4
5	PSPHY 105	Mathematical Physics and Classical Mechanics/ Data Science*/Any other Engineering Technology course*	3	1	0	4
Laboratory Courses						
6.	PSPHY LB1	Laboratory for Solid State Materials	0	0	4	2
7.	PSPHY LB2	Laboratory for Computational Physics	0	0	4	2
	Total					24

Subject: Quantum Mechanics [Code: PSPHY 101]	Year & Semester: M.Sc. Physics I[st] Year & I[st] Semester.		Credits: 4	L: 3	T: 1, P: 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term		
	30 Marks	10 Marks	60 Marks		

Sr.No	Course outcomes
CO1	Students will learn experimental outcomes for measurement of observables on simple quantum systems using the superposition principle. Apply the uncertainty principle and heuristic arguments to obtain rough descriptions of quantum systems.
CO2	Students will be able to apply Schrodinger equation to particle in one – dimensional potential well and to Linear Harmonic Oscillator.
CO3	Students will be to explain Spin, Pauli Spin matrices, Wigner – Eckert theorem.
CO4	Students will be able to explain Time independent perturbation theory and stark effect in hydrogen atom.

Course contents		Lectures required
Unit	Particulars	
01	Mathematical tools of Quantum Mechanics: Linear vector space, State space, Dirac notation and Representation of State Spaces, Concept of Ket's,Bra's and Operators, Uncertainty Relations, Commutation and Compatibility, Change of basis, Unitary operators. State function and its interpretation, Matrix Representation of State Vectors and operators, Continuous Basis. Relation between a State Vector and its Wave function, numerical problems and skills.	10
02	Basic Quantum Mechanics and applications: Schrodinger's equation and its applications: Particle in one-dimensional potential well (finite and infinite depth) and its energy states; Linear harmonic oscillator; Free particle wave function. Solution of the Linear Harmonic Oscillator with Operator Method, Coherent States.Angular momentum and eigenfunctions, numerical problems and skills.	10
03	Generalised angular momentum: Infinitesimal rotation, Generator of rotation, Commutation rules, Matrix representation of angular momentum operators, Spin, Pauli spin matrices, Rotation of spin states, Coupling of two angular momentum operators, Clebsch Gordon coefficients, Symmetries- Irreducible spherical tensor operators, Wigner-Eckert theorem and its applications, Space inversion, numerical problems and skills.	10
04	Quantum Theory of Hydrogen Atom and approximation methods: Angular momentum and the eigenfunctions. Energy states associated wave functions of Hydrogen atom, numerical problems and skills. Approximation methods - Time-independent perturbation theory for non-degenerate and degenerate states. Applications: Anharmonicity, Helium atom, Stark effect in hydrogen atom, Variational methods: Helium atom. Scattering: 1D cases and particle-wave analysis, numerical problems and skills.	10

Recommended Books		
Sr. No.	Text Books	Author
01	Introduction to Quantum Mechanics	David J. Griffiths
	Reference Books	
01	Quantum Mechanics and Applications	N. Zettili
02	Modern Quantum Mechanics	J.J Sakurai

Subject: Classical Electrodynamics [Code: PSPHY 102]	Year & Semester: M.Sc. Physics I[st] Year & I[st] Semester.		Credits 4 · L 3 · T 1 · P 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	Students will evaluate Poisson and Laplace equations, Greens Function, Boundary value problems for dielectrics.
CO2	Students will understand Maxwell's equations, Gauge transformations, Poynting's theorem,
CO3	Students will be able to explain Radiating Systems and Multipole fields.
CO4	Students will understand Relativistic Electrodynamics, covariant formalism of Maxwell equations.

Course contents		Lectures require
Unit	Particulars	
01	Electrostatics Poisson and Laplace equations, Dirichlet and Neumann boundary conditions; Boundary value problems: Method of images, Laplace equation in Cartesian, spherical and cylindrical coordinate systems, applications; Green function formalism: Green function for the sphere, expansion of Green function in spherical coordinates; Multipole expansion; Boundary value problems for dielectrics; Magnetostatics: vector potential, magnetic induction for a circular current carrying loop, magnetic materials, boundary value problems, Magnetic shielding, magnetic field in conductors, numerical problems and skills.	10
02	Electrodynamics Maxwell's equations, Gauge transformations, Poynting's theorem, Energy and momentum conservation; Electromagnetic waves: wave equation, propagation of electromagnetic waves in non-conducting medium, reflection and refraction at dielectric interface, total internal reflection, Goos-Hänchen shift, Brewster's angle, complex refractive index, numerical problems and skills.	10
03	Radiating Systems and Multipole fields: Retarded potential, field and radiation of a localized oscillating source, electric dipole fields and radiation, quadrupole fields, multipole expansion, energy and angular momentum, multipole radiations; Scattering: scattering at long wavelengths, perturbation theory, Rayleigh scattering; Radiation by Moving Charges: Lienard- Weichert potential, radiation by nonrelativistic and relativistic charges, angular distribution of radiations, distribution of frequency and energy, Thomson's scattering, bremsstrahlung in Coulomb collisions, numerical problems and skills.	10
04	Relativistic Electrodynamics Covariant formalism of Maxwell's equations, transformation laws and their physical significance, relativistic generalization of Larmor's formula, relativistic formulation of radiation by single moving charge, numerical problems and skills.	10

Recommended Books		
Sr. No.	Text Books	Author
01	Classical Electrodynamics, John Wiley (Asia) (1999).	J. D. Jackson,
	Reference Books	
01	Electromagnetic Waves and Radiating Systems, Prentice Hall (1995).	E. C. Jordan and K. G. Balmain,
02	Introduction to Electrodynamics	D.J Griffiths

Syllabus formulated during Week Long Curriculum Development Workshop (25-29 July 2022)

Subject: Statistical Mechanics (Code: PSPHY 103)	Year & Semester: M.Sc. Physics I[st] Year & I[st] Semester.	Credits 4, L 3, T 1, P 0

Credits	L	T	P
4	3	1	0

Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	Students will be able to distinguish different systems on the basis of ensemble theory.
CO2	Students will be able to evaluate systems based on Bose Einstein and Fermi Dirac Statistics
CO3	Students will be able to explain phase transition and evaluate Ising system.
CO4	Students will be able to interpret significance of fluctuations.

Course contents		Lectures required
Unit	Particulars	
01	Connection between statistics and thermodynamics; Concept of microstates, phase space and its connection to Entropy; Classical Ideal Gas and the Maxwell Boltzmann Distribution, Entropy of mixing and Gibbs Paradox; Liouville's Theorem, Ensembles, and Partition Function calculation for various systems; Energy fluctuations in the Canonical Ensemble; Grand Canonical Ensemble; Number Density and Energy Fluctuations in the Grand Canonical ensemble, numerical problems and skills.	08
02	Quantum Statistics and calculation of the Density matrix for various systems; Indistinguishability of Particles, Symmetric and Anti-Symmetric wave functions and calculation of the Bose-Einstein and Fermi-Dirac Distribution for a quantum Ideal Gas; Thermodynamic behaviour of an Ideal Bose Gas, Bose-Einstein Condensate; Thermodynamic behaviour of an ideal Fermi gas, Pauli Para magnetism; Cluster expansion techniques for interacting systems, numerical problems and skills.	10
03	Phase Transitions: General concepts of phase transitions, order parameter, continuous transition, Landau theory of phase transition, concept of critical phenomena, critical exponents, Ising model and Van der Waals gas, exact solution of the Ising model in 1D; Description of Einstein-Smoluchowski theory of Brownian motion as a stochastic process; Basic ideas behind the Fokker-Planck, fluctuation-dissipation theorem, numerical problems and skills.	12
04	Thermodynamic fluctuations, Spatial correlations in a fluid, The Einstein-Smoluchowski theory of the Brownian motion, The Langevin theory of the Brownian motion, Approach to equilibrium: the Fokker-Planck equation, Spectral analysis of fluctuations: the Wiener-Khintchine Theorem, The fluctuation-dissipation theorem, numerical problems and skills.	10
Recommended Books		

Sr. No.	Text Books	Author
01	Statistical Mechanics	Pathria, R. K.
	Reference Books	
01	Statistical Mechanics	Kerson Huang
02	Fundamentals of statistical and thermal physics	F Reif

Subject: Condensed Matter Physics (Code: PSPHY 104)	Year & Semester: M.Sc. Physics I[st] Year & I[st] Semester.	Credits 4, L 3, T 1, P 0	
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	Students will be able to explain Reciprocal lattice, Brillouin zone, structure factor.
CO2	Students will be able to distinguish different materials on the basis of free electron theory.
CO3	Students will be able to explain Piezoelectricity, pyro- and ferroelectricity
CO4	Students will be able to distinguish between Diamagnetism, paramagnetism, Ferromagnetism and antiferromagnetism,

Course contents		Lectures required
Unit	Particulars	
01	Crystal structure, symmetry and diffraction The Structure of Materials & Technological Relevance, Point symmetry, The 32 crystal classes, Reciprocal lattice; Brillouin zones, Laue condition and Bragg law, Structure factor; defects & Importance, numerical problems and skills.	08
02	Free Electron Model & Energy Bands Failure of free electron model, The quantum theory of Free Electron, The Fermi Statistics, The Fermi distribution function, Energy bands in Solids, Band symmetry in k-space, Brillouin Zones, The nearly free electron and tight binding Model, Calculation of energy bands, Distinction between Materials, numerical problems and skills.	12
03	Dielectric properties of solids Dielectric constant and polarizability (susceptibility), Dipolar polarizability, ionic and electronic polarizability, Piezoelectricity; pyro- and ferroelectricity, Light propagation in solids, numerical problems and skills.	10
04	Classification of materials; Diamagnetism, paramagnetism, Landau theory of Diamagnetism, Quantum theory of paramagnetism, Ferromagnetism and antiferromagnetism, Magnetic resonance, Multiferroic Materials, numerical problems and skills.	10

Recommended Books		
Sr. No.	Text Books	Author
01	Solid State Physics	Nell W Ashcroft and N D Mermin
	Reference Books	
01	Elementary Solid-State Physics	M A Omar
02	Introduction to Solid-State Physics	Charles. Kittle

Subject: Advanced Topics in Mathematical Physics and Classical Mechanics (Code: PSPHY 105)	Year & Semester: M.Sc. Physics I[s t]Year &I[st] Semester.		Credits 4, L 3, T 1, P 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Credits	L	T	P
4	3	1	0

Sr. No.	Course outcomes
CO1	Student be able to apply methods of functions of complex variables for calculations of integrals, Work with tensors.
CO2	Upon completion of the course, the student should be able to understand basic theory of Special functions tensor analysis, Functions of complex variables
CO3	Students are expected to understand need of classical mechanics in solving problems relate to classical systems.
CO4	Upon completion of the course, the student should be able to understand Hamiltonian Mechanics

Course contents		Lectures required
Unit	Particulars	
01	Complex Analysis: Functions, derivatives, Cauchy-Riemann conditions, analytic and harmonic functions, contour integrals, Cauchy-Goursat Theorem, Cauchy integral formula; Series: Special functions: Legendre, Hermite, Laguerre and Bessel functions, Green's function and its applicationsLaplace and Fourier Transform, numerical problems and skills.	10
02	Tensors : Description of tensors in detail, transformation laws, invariant tensors, tensor fields, Integral theorems(The divergence theorem, Green's theorem in plane, Stoke's theorem), a Unification of Integral theorem. Group theory: Introduction, definitions and terminology(subgroups of cosets, direct of groups, cyclic group), Matrix groups(orthogonal, unitary) Lie groups, numerical problems and skills.	10
03	Central force problem: Two body problem in central force, Equations of motion, effective potential energy, nature of orbits, Virial theorem, Kepler's problem, condition for closure of orbits, scattering in a central force field, Centre of mass and laboratory frame, numerical problems and skills.	10
04	Lagrangian formulation: Euler Lagrangian equation, Hamilton's principle, De Alembert's principle, Conservation theorems and symmetry properties. Hamiltonian formulation: Legendre transformations, Hamilton's equations, symmetries and conservation laws in Hamiltonian picture, principle of least action, canonical transformations, Poisson brackets, Hamilton- Jacobi theory, introduction to classical field theory, numerical problems and skills.	10

Recommended Books		
Sr. No.	Text Books	Author
01	Mathematical Methods for Physicists	G.B. Arfken, H.J. Weber and F.E. Harris,
	Reference Books	
01	Mathematical methods in physical sciences	Mary L Boas
02	Classical Mechanics	Herbert Goldstein
03	An Introduction to Mechanics	D. Kleppner

<table>
<tr><td rowspan="2">Subject: Laboratory for Solid State Materials
(Code: PSPHY LB1)</td><td colspan="2" rowspan="2">Year & Semester: M.Sc. Physics
Ist Year & Ist Semester.</td><td>Credits</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="4">End-Term</td></tr>
<tr><td></td><td>10 Marks</td><td colspan="4">90 Marks</td></tr>
</table>

Sr.No.	Course outcomes
CO1	Students will be able to explain basic properties of Solid-State Materials.
	Students will be able to know how resistivity ,Hall coefficient and other parameters of semiconductor vary with temperature.
CO2	Students will be able to calculate band gap, hall coefficient, coercivity, remanence and saturation magnetization, dielectric constant of materials
CO3	Students will be able to explain field dependence of magnetoresistance of a given semiconductor sample.
CO4	Students will be able to distinguish between , paramagnetism, Ferromagnetism and antiferromagnetism by measuring magnetic susceptibility

List of Experiments	

Experiment No.1: To Study the temperature dependence of resistivity of semiconductor and to determine band gap of experimental material (Ge).
Experiment No. 2: To determine Hall Coefficient, carrier concentration of semiconductor at room temperature.
Experiment No. 3: To study the variation of Hall coefficient with temperature.
Experiment No. 4: To determine Planck's constant and work function using photoelectric effect.
Experiment No. 5: To Verify inverse square law of radiation using photoelectric effect.
Experiment No.6: To measure dielectric constant of a ferroelectric material as a function of temperature and to observe ferroelectric to Para electric transition.
Experiment No. 7: To study the magnetic field dependence of magnetoresistance of a given semiconductor sample.
Experiment No.8: To plot the magnetic hysteresis loop for a ring-shaped massive iron core and to determine coercivity, remanence and saturation magnetization.
Experiment No. 9: Study of Thermoluminescence of F- centers in alkali halides crystals
Experiment No.10: To measure the magnetic susceptibility of paramagnetic solid by Gouy's method.

Recommended Text Books		
Sr. No.	Name of the book	Author
01	Lab in sky	MA Shah & Surbhi
02	Advanced practical physics for students	BL Worsnop & HT Flint

Subject: Laboratory for Computational Physics (Code: PSPHY LB2)	Year & Semester: M.Sc. Physics I[st] Year & I[st] Semester.		Credits 2, L 0, T 0, P 4
Evaluation Policy	Mid-Term	Class Assessment	End-Term
		10 Marks	90 Marks

Sr.No.	Course outcomes
CO1	Students will be able to explain fundamentals of MATLAB.
CO2	Students will be able to write MATLAB Scripts.
CO3	Students will be able to apply programming knowledge to solve mathematical problems
CO4	Students will be able to construct, visualize and analyze algorithm to simulate systems and problems

List of Experiments

Experiment No. 1: Write MATLAB script to simulate the decay of radioactive nucleus.
Experiment No. 2: Write MATLAB script for the numerical solution of equation of motion for a simple pendulum using the Euler method.
Experiment No. 3:Write MATLAB script for the numerical solution of equation of motion for a simple pendulum using the Runge Kutta method.
Experiment No. 4: Write a MATLAB script for the numerical solution of damped pendulum.
Experiment No. 5: Write a MATLAB script to simulate the planetary motion of earth around the sun.
Experiment No. 6:Write a MATLAB script to simulate the random walk.
Experiment No. 7: Write a MATLAB script to solve time dependent Schrodinger equation in 1D for particle in a box problem.
Experiment No. 8: Write a MATLAB script to simulate the Ising model of a ferromagnet.

Recommended Books

Sr. No.	Name of the book	Author
01	Getting start with MATLAB A Quick Introduction for Scientists &Engineers	Rudra Pratap

SEMESTER – II

Core Courses

S. No	Course Code	Theory Courses	L	T	P	Credit
1.	PSPHY 201	Atomic & Molecular Physics	3	1	0	4
2.	PSPHY 202	Applied Optics and Photonics	3	1	0	4
3.	PSPHY 203	Nuclear and Particle Physics/ *Artificial Intelligence	3	1	0	4
4.	PSPHY 204	Semiconductor Physics and Devices	3	1	0	4
5.	PSPHY 205	Low Dimensional Physics	3	1	0	4
	Laboratory Courses					
6.	PSPHY LB3	Laboratory for Optics and Photonics	0	0	4	2
7.	PSPHY LB4	Laboratory for Synthesis of Nanomaterials	0	0	4	2
	Total					**24**

Subject: Atomic and Molecular Physics [Code: PSPHY 201]	Year & Semester: M.Sc. Physics I[st] year & 2[nd]Semester.	Credits: 4, L: 3, T: 1, P: 0

Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	Students will be able to distinguish between Normal Zeeman effect and Anomalous Zeeman effect and will understand Hyperfine structure and Lamb shift.
CO2	Students will be able to understand spectroscopic selection rules.
CO3	Students will be able to explain LS Coupling, J-J Coupling and Paschen Back effect.
CO4	Students will be able to interpret Infrared Spectroscopy and Rotational Raman Spectra

Course contents		Lectures required
Unit	Particulars	
01	HYDROGEN ATOM STRUCTURES Solution of Schrödinger's Equation for one Electron System, Quantum Numbers (n, l, m) and Wave Function of the H Atom, Comparison with the Bohr's Model, The Normal Zeeman Effect, Anomalous Zeeman Effect, Relativistic Correction of Energy Terms, The Electron Spin, The Stern-Gerlach Experiment, Spin-Orbit Interaction and Fine Structure, Hyperfine Structure, Lamb Shift, Numerical Problems & skills.	10
02	TWO VALANCE ELECTRON ATOMS The Helium Atom, Approximation Models, Symmetry of the Wave Function, Consideration of Electron Spin, Pauli's Exclusion Principle, spectroscopic selection rules, Helium Spectrum, Numerical Problems & skills.	10
03	ANGULAR PROBLEMS IN MANY-ELECTRON ATOMS Coupling Schemes for Electronic Angular Momenta, The LS-Coupling Approximation, Allowed Term in LS Coupling, Fine Structure in LS Coupling, J-J Coupling. Interaction with External Field: Zeeman, Paschen-Back and Stark Effects, Numerical Problems & skills.	10
04	MOLECULAR PHYSICS Molecular Structure and Molecular Spectra, Rotational, Vibrational, Rotational-Vibrational and Electronic Spectra of Di-atomic Molecules, Selection Rules, ESR Spectroscopy: Introduction, g-factor, Electron-Nucleus hyperfine Coupling, Double Resonance in ESR, Electron-Electron Coupling, Infrared Spectroscopy: The Vibrating Diatomic Molecules, the Diatomic Vibrating-Rotator Spectra of Diatomic Molecules, Raman Spectroscopy: Introduction, Pure Rotational Raman Spectra, Vibrational Raman Spectra, Numerical Problems & skills.	10

Recommended Books		
Sr. No.	Text Book	Author
01	Fundamentals of Molecular Spectroscopy, 4[th] edition, McGraw-Hill, New York.	C.N. Banwell
	Reference Books	
01	Atomic and Molecular Spectra: Laser	Raj Kumar
02	Atoms, Molecules and Photons, 3[rd] edition, Springer.	Wolfgang D,

Syllabus formulated during Week Long Curriculum Development Workshop (25-29 July 2022)

Subject: Applied Optics and Photonics **Course Code: [PSPHY 202]**	Year & Semester: M.Sc. Physics I[st] Year &2[nd] Semester.		Credits 4 / L 3 / T 1 / P 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	Develop fundamental concepts of optics
CO2	Analyze the behaviour of light through different optical phenomena
CO3	Analyze basic optical components
CO4	Develop an understanding of concepts and components of optical fibre

Course contents		Lectures required
Unit	Particulars	
01	Introduction: Overview of light models: geometrical, electromagnetic and quantum. Basic concepts: refractive index, ray and optical length. Light propagation: rays in homogenous and heterogeneous media. Reflection and refraction laws. Fundamentals of Electromagnetic Optics: Electromagnetic waves characteristics. Electromagnetic spectrum. Plane and spherical waves, Intensity, Coherence, numerical problems & skills.	10
02	Polarization: Unpolarized, partially polarized and polarized lights. Polarizers. Half- and quarter-wave plates Classical interaction of light with matter: Absorption. Chromatic dispersion. Scattering. Interferences and diffraction: Double-slit Young's experiment. Multiple-wave interferences. Diffraction phenomena. Huygens-Fresnel Principle. Fresnel and Fraunhofer diffraction. Fraunhofer diffraction through different apertures: rectangular and circular apertures. Diffraction gratings, numerical problems and skills.	10
03	Imaging systems: Paraxial Optics. Principal planes and points. Focal planes and points. Spherical refractive surface. Mirrors. Prisms. Thin lenses. Thick lenses. Basic optical instruments. Quantum Optics: Photons. Basic processes between energy levels: absorption, spontaneous emission and stimulated emission, numerical problems and skills.	10
04	Optical waveguides: optical fibers, integrated optics. Control of light: electro-optics, acousto-optics, nonlinear optics. Scattering: spontaneous and stimulated scattering, Rayleigh, Brillouin, and Raman scattering. Photonic components: multiplexers, switches, modulators, filters. Applications in optical communication and optical sensor and measurement technology numerical problems and skills.	10

Recommended Books		
Sr. No.	Text Book	Author
01	Optics	E. Hecht.Addison Wesley 2000.
	Reference books	
01	Fundamentals of Photonics"	B.E.A. Saleh and M.C. Teich. Wiley, 1991.
02	Principles of Optics	Max Born and Emil Wolf

Subject: Nuclear and Particle Physics Course Code: [PSPHY 203]	Year & Semester: M.Sc. Physics Ist Year & 2ndSemester.		Credits: 4, L: 3, T: 1, P: 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	Familiarization with basic nuclear structure.
CO2	Understanding the behaviour of fundamental particles.
CO3	To apply fundamental physics knowledge to more complex nuclear and particle physics topics.
CO4	Formulate solutions to problems in nuclear and particle physics involving new concepts with limited guidance.

Course contents		Lectures required
Unit	Particulars	
01	Bulk properties of Nuclei Nuclear sizes: Rutherford Scattering, Electron scattering, mass distribution Number density and Fermi momentum of nucleus: Number density of nucleons, fermi momentum, Fermi gas model, Thomas - Fermi approximation, Nuclear Masses: the binding energies, Semi- empirical mass formula (Weizacker- Bethe mass formula), Liquid Drop Model, Application of the mass formula (the stability line, the Heisenberg Valley, stability with respect to fission) Shell Structure : Magic numbers, explanation of magic numbers by Mean field theory, the mean field energy levels for infinite square – well potential, Harmonic Oscillator model,	10
02	The Nuclear forces of Two – Body systems Fundamentals of nuclear force, range of nuclear force, radial dependence, state dependence of nuclear force, general structure of nuclear force, Static potentials (Velocity independent potentials and Velocity dependent potentials), properties of Deuteron, Nucleon- Nucleon scattering, Meson theory, Hartree- Fock theory, Alpha decay, Electromagnetic transitions,	10
03	Introduction to Fundamental Interactions, Strength and range of the interaction, Yukawa potential in Born approximation, Fundamental particles: Bosons and fermions, Higgs boson, Quarks, leptons, anti- particles, more quantum numbers, Feynman diagrams with examples, composite particles: Meson and Baryon, Hadron spectroscopy, Meson classification, baryon classification,	10
04	Various types of interactions Gravitational, electromagnetic, and weak and strong interactions and their mediating quanta, Conservation rules in fundamental interactions. Charge symmetry and charge independence, Parity and charge conjugation, strangeness and decay modes, Isospin and its conservation. The idea of eight-fold way and quarks.	10

Recommended Books		
Sr. No.	Text Book	Author
01	Introduction to Nuclear Physics	Heral Enge,
	Reference books	
01	Fundamentals of Nuclear Physics	Noboru Takigawa and Washiyana
02	Introduction to Elementary Particles	David J.Griffths
03	Introductory Nuclear Physics	Samuel S. Wong

<table>
<tr><td colspan="2">Subject: Semiconductor Physics and Devices
Course Code: PSPHY 204</td><td colspan="2">Year & Semester: M.Sc. Physics
Ist Year &2ndSemester.</td><td>Credits 4 | L 3 | T 1 | P 0</td></tr>
<tr><td colspan="2" rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td>End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td>60 Marks</td></tr>
</table>

Credits	L	T	P
4	3	1	0

Sr.No.	Course outcomes
CO1	Understand doping of materials and other related phenomena
CO2	Formation of p-n junctions, p-n junction devices and their wide range of applications
CO3	Understand metal-semiconductor contacts resulting in ohmic vs. Schottky (rectifying) junctions.
CO4	Application of materials in devices and efficiency

Course contents		Lectures required
Unit	Particulars	
01	Physics of semiconductors: Review of Energy Bands and Energy Gap, Fermi level in intrinsic and extrinsic semiconductors, Dependence of fermi level on temperature and carrier concentration, Electrical Conductivity, Theory of p-n junctions – diode and transistor: p-n junction under thermal equilibrium, forward bias, reverses bias, carrier density, current, electric field, barrier potential. V-I characteristics, junction capacitance and voltage breakdown, numerical problems and skills.	10
02	Transistors: Bipolar junction Transistor (BJT), Ebers Moll Model, Analysis of CE amplifier using h parameters, The T-network equivalent circuit, constants of CB and CE amplifier using emitter, base, collector resistance, Biasing technique to BJT, stabilization factor, temperature stabilization, operating point, fixed bias, emitter feedback bias, voltage feedback bias. Field-Effect Transistors (FET) and MOSFET: Structure, Working, Derivations of the equations for I-V characteristics under different conditions.	10
03	Negative feedback, effect of negative feedback on input/output resistances and voltage gain, gain stabilization, effect of negative feedback on band width, voltage series feedback, voltage shunt feedback applied to BJT, current series feedback, current shunt feedback applied to BJT	10
04	Semiconducting devices: Optical devices: optical absorption in a semiconductor, electron-hole generation. Solar cells, conversion efficiency, heterojunction solar cells, Photodetectors photo conductors, photodiode, p-i-n diode, Light emitting diode (LED) – generation of light, internal and external quantum efficiency. Modern semiconducting devices: CCD – introduction to Nanodevices, fundamentals of tunnelling devices, Logic gates.	10

Recommended Books		
Sr. No.	Text Books	Author
01	Solid State Electronic Devices	B.G. Streetman, S.K. Banerjee
	Reference books	
01	Physics of Semiconductor Devices	S.M. Sze
02	Electronic Devices and Circuits	Millman and Halkins

Subject: Low Dimensional Physics Course Code: PSPHY 205	Year & Semester: M.Sc. Physics I[st] year &2[nd]Semester.		Credits 4, L 3, T 1, P 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	Understanding the physics of low-dimensional systems
CO2	Understanding the fundamental properties of low-dimensional systems
CO3	To understand the thermodynamics of low temperature materials
CO4	To apply the knowledge of low-dimensional systems in various devices

Course contents		Lectures required
Unit	Particulars	
01	Quantum electron transport (Landauer formula); introduction to quantum wells, quantum wires and quantum dots wave functions and energy levels. Fullerene and Carbon nanotubes (single walled and multi-walled)	10
02	Photonic crystals. Elementary idea about Graphene. Idea of spin transport in low dimensional systems (Spintronics).	10
03	Production of low temperatures; cryostat design and experimental techniques applied to low temperature; thermometry; specific heat, transport phenomena, thermal, electrical and magnetic properties; superconductivity, applications of superconductivity; superfluidity and associated phenomena.	10
04	Thermodynamics and liquefaction of gases; cryostat design and vacuum techniques; materials; transport phenomena, Fermi surfaces, magnetism, optical properties of solids, techniques of measurement, superconductivity, superfluidity, paramagnetic and nuclear adiabatic demagnetization.	10

Recommended Books		
Sr. No.	Text Books	Author
01	Physics of Low-dimensional semiconductors	John H. Davies
	Reference books	
01	Transport in Nanostructure	D.K. Ferry and S.M. Goodnick
02	The Physics of Low Dimensional Materials	F.J. Owens

Subject: Laboratory for Optics and Photonics **Course Code: PSPHY LB3**	Year & Semester: M.Sc. Physics I[st] year &2[nd]Semester.		Credits: 2, L: 0, T: 0, P: 4
Evaluation Policy	Mid-Term	Class Assessment	End-Term
		10 Marks	90 Marks

Sr.No.	Course outcomes
CO1	Apply the concepts of optics to evaluate various parameters
CO2	Analyze behavior of light under different apparatus settings
CO3	Develop understanding of optical instruments
CO4	Calculate and interpret scientific data

List of Experiments

Experiment No. 1 To find the wavelength of sodium light using Newton's rings.
Experiment No. 2 Determination of wavelength of monochromatic light with the help of Fresnel Bi-Prism.
Experiment No. 3 To find angle of prism, angle of minimum deviation and refractive index of prism.
Experiment No. 4 Determination of Plank's constant by measuring radiation in a fixed spectral range.
Experiment No. 5 To verify Malus Law.
Experiment No. 6 To determine splitting of lines by Zeeman effect experiment.
Experiment No. 7 Measurement of coherence length of laser using Michelson interferometer.
Experiment No. 8 To determine the specific rotation of sugar Lauren's half shade polarimeter.
Experiment No. 9 Determine of line width of a laser using monochromator.
Experiment No. 10 Thickness of enamel coating on a wire by diffraction.

Recommended Text Books

Sr. No.	Name of the book	Author
01	Lab in Sky	MA Shah & Surbhi
02	Advanced practical physics for students	BL Worsnop & HT Flint

Subject: Laboratory for Synthesis of Nanomaterials **Course Code: PSPHY LB4**	Year & Semester: M.Sc. Physics Ist year &2ndSemester.		Credits 2, L 0, T 0, P 4
Evaluation Policy	Mid-Term	Class Assessment	End-Term
		10 Marks	90 Marks

Credits	L	T	P
2	0	0	4

Sr. No.	Course outcomes
CO1	Students will d develop understanding about material synthesis.
CO2	Students will be able to learn solid state reaction, sol gel method etc.
CO3	Students will be able to apply various methods to prepare nano materials.
CO4	Students will be able to prepare thin films

List of Experiments

Experiment No. 1: Synthesis of nanomaterial sample using Sol-gel technique.
Experiment No. 2: Synthesis of polycrystalline sample using solid state reaction technique
Experiment No. 3: Synthesis of thin film sample using sputtering of target material.
Experiment No. 4: Synthesis of nanomaterial using Ball Milling of bulk sample.
Experiment No. 5: Synthesis of nanomaterial using hydrothermal method
Experiment No. 6: Synthesis of nanomaterial using auto combustion method.
Experiment No. 7: Synthesis of nanomaterial using Co-precipitation method.
Experiment No. 8: Synthesis of nanomaterial using Sonochemical and spark discharge route.

Recommended Text Books

Sr. No.	Name of the book	Author
01	Synthesis and Applications of Nanoparticles	Atulthakur, Preeti Thakur

SEMESTER – III

Students have to choose 4 electives (Either from below or from List overleaf)/

S. No	Course Code	Courses - Department Elective Courses	L	T	P	Credits
1.	PSPHY EL1	Nanoscience and Nanotechnology	3	0	0	3
2.	PSPHY EL2	Renewable Sources of Energy	3	0	0	3
3.	PSPHY EL3	Quantum Computation and Information	3	0	0	3
4.	PSPHY EL4	Atmospheric and Environmental Physics	3	0	0	3
5.	PSPHY EL5	Quantum Logic and Simulations	3	0	0	3
6.	PSPHY EL6	Defects in Solid State Physics	3	0	0	3
7.	PSPHY EL7	Photovoltaic Systems	3	0	0	3
	Laboratory Core Courses					
9.	PSPHY LB5	Laboratory for Characterization of Materials	0	0	4	2
10.	PSPHY LB6	Electronics Tinkering Laboratory.	0	0	4	2
	Total					**16**

Subject: Nanoscience & Nanotechnology **Course Code: PSPHY EL1**	Year & Semester: M.Sc. Physics 2nd Year & 3rd Semester.	Credit 3, L 3, T 0, P 0

Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	To understand the basic concepts of thermoelectric materials.
CO2	To understand thetechniques for characterizing &synthesis of thermoelectric materials
CO3	Understanding of the thermoelectric devices andrecent development in properties of Penta tellurides
CO4	To understand the recent developments in the Penta tellurides.

Course contents		Lectures required
Unit	Particulars	
01	The scientific revolutions – Nanoscience, Nature and scope, surface to volume ratio, quantum effects- classification of nanocrystals - dimensionality and size dependent phenomena; Quantum dots, Nanowires and Nanotubes, Preparations Methods, Top down and bottom up, Special nanomaterials - Carbon based nanomaterials, Graphene, numerical problems and skills	10
02	Properties of materials &nanomaterials, Electronic Properties, Photoconductivity, Optical absorption & transmission, Photoluminescence, Fluorescence, Phosphorescence, Electroluminescence, Important properties in relation to nanomagnetism- Nanoscale magnetism –Transport in a magnetic field, Dielectric properties	10
03	Photoluminescence, NMR, ESR and Light Scattering methods UV-Vis-NIR, FTIR, FT-Raman. Scanning Electron Microscopy: HRTEM- X ray Diffraction, Industrial applications of Nanomaterials: Nanomaterials in bone substitutes & Dentistry, Biochips- analytical devices, Biosensors	10

Recommended Books		
Sr. No.	Text Books	Author
01	Recent Trends in Thermoelectric Materials	TERRY M. TRITT.
	Reference Books	
01	Thermoelectric Energy Conversion Basic Concepts and Device Applications	Diana Dávila Pineda AlirezaRezania.
02	Science of small	MA Shah & KA Shah

Subject: Renewable Sources of Energy Course Code: PSPHY EL2	Year & Semester: M.Sc. Physics 2nd Year & 3rd Semester.		Credit: 3, L: 3, T: 0, P: 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	The students will be able to understand the various types of energy sources.
CO2	Students will be able to apply environmental implications of energy usage,
CO3	Students will be able to design solar thermal energy systems.
CO4	The students will be able to evaluate the hydrogen production and storage

Course contents		Lectures required
Unit	Particulars	
01	Relevance of Renewable Energy in relation to depletion of fossil fuels, Environmental considerations, Green energy, sustainable energy, centralized and decentralized energy, Wind Energy, wind turbines, economics and environmental impact; Bioenergy. Biomass, Energy from waste	10
02	Sun as a source of energy, Basic Sun earth geometry Flat plate and evacuated tubular collectors, efficiency of collectors, overall heat loss coefficient and heat transfer correlations, Solar thermal applications like solar cooker and solar water heaters, solar dryers, active and passive heating of buildings, Daylighting, Refrigeration and Cooling	10
03	Hydrogen Energy, Solar Hydrogen through photo electrolysis and photocatalytic process. Physics of material characteristics for production of solar hydrogen, Brief discussion of various storage processes, new storage modes, Various factors relevant for safety, use of Hydrogen as fuel, use in vehicular transport, hydrogen for electricity generation, Fuel Cells	10

Recommended Books		
Sr. No.	Text Book	Author
01	Renewable Energy.	Twidell and Wier, E & FN Spon Ltd.
	Reference Books	
02	Renewable Energy: Power for sustainable future,	Godfrey Boyle, Oxford University Press
03	Hydrogen and Fuel Cells:	Bent Sorensen & Giusepp Spazzafumo, Academic Press

Subject: Quantum Computation and Information **Course Code: PSPHY EL3**	Year & Semester: M.Sc. Physics 2nd year & 3rd Semester.		Credit 3 | L 3 | T 0 | P 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	Students will be able to learn basics of Quantum Computation and Information.
CO2	Students will get familiar with the concept of qubits, entanglement, etc.
CO3	Students will learn quantum Teleportation.
CO4	Students will understand Quantum Algorithm

Course contents		Lectures required
Unit	Particulars	
01	Introduction to the Second Quantum Revolution, Overview of basic quantum phenomena, particles, waves, interference, quantized energy levels, measurements, Stern-Gerlach experiment, spins, Two-level quantum systems, qubits, Representing quantum states as complex vectors (Hilbert space), Superposition states, Dirac bra-ket notation, Operators, observables, Bloch Sphere, Distinguishability of states, Representation of multi-qubit states as direct products	15
02	Entanglement, EPR, Bell inequalities, CHSH inequality, GHZ states, Causality and the no-signaling condition on ‘spooky action at a distance’, No cloning theorem, quantum teleportation, quantum dense coding	10
03	Concept of Quantum Algorithm, Deutsch Algorithm, Deutsch - Jozsa Algorithm, Quantum Fourier transform, Quantum Search Algorithm	5

Recommended Books		
Sr. No.	Text Book	Author
01	Quantum Computation and Quantum Information	M. A. Nielsen and Isaac L. Chaung
	Reference Books	
01	An Introduction to Quantum Computing	Philip Kaye, Raymond Laflamme

Subject: Atmospheric & Environmental Physics **Course Code: PSPHY EL4**	Year & Semester: M.Sc. Physics 2nd year & 3rd Semester.		Credit 3 / L 3 / T 0 / P 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Credit	L	T	P
3	3	0	0

Sr. No.	Course outcomes
CO1	Students will be able to learn basics of Atmospheric physics
CO2	Students will get familiar with the concept of Electromagnetic Radiation, Energy balance at the earth's surface, transport of pollution in water and air.
CO3	Students will learn about Energy losses, Energy resources and their exploitation
CO4	Students will understand Earthquakes, Seismic waves etc,

Course contents		Lectures required
Unit	Particulars	
01	Introduction: Source of ionization, formation of an ionized layer, The ionospheric regions, Distribution of ions in the top side of ionosphere, Magnetic field variation and concepts of atmospheric dynamo and motor, Moments in the atmospheric plasma and neutral atmospheric interaction, currents in ionosphere Basics of the atmospheric structure: Electromagnetic radiation, absorption and emission. The radiation balance and the greenhouse gases. Energy balance at the earth's surface. Water balance. Hydrological cycle. The water movements in ground and soil. Transport of pollution in water and air.	10
02	Concept and scope of environmental Physics with respect to human environment: Energy use and efficiency in buildings. Energy losses, calculation of energy losses, energy g ains. Air regulation in buildings, heat pumps,Energy resources and their exploitation.Energy use patte rn in different parts of the world and its impact on the environment. CO_2, emission in the atmosphere.	10
03	Biological Invasion: concept; pathways, process, mechanism, impacts, examples of major invasive species in India, Earthquakes, distribution and mechanism. Seismic waves. Environmental applications in meteorology, hydrology and geophysics. Environmental Management.	10

Recommended Books		
Sr. No.	Text Books	Author
01	Principles of Environmental Physics	John L Monteith & Mike H Unsworth
	Reference Books	
01	Physics and the Environment	Kali Forinash
02	Environmental Physics: Sustainable Energy and Climate Change	Egbert Boeker and Rienk van Grondelle

Subject: Quantum Logic and Simulations **Course Code: PSPHY EL5**	Year & Semester: M.Sc. Physics 2nd year & 3rd Semester.		Credit 3 | L 3 | T 0 | P 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr.No.	Course outcomes
CO1	Develop fundamentals of quantum computing
CO2	Understand fundamentals of Quantum Cryptography and Entanglement.
CO3	Design quantum algorithms to solve problems
CO4	Develop understanding about error correction.

Course contents		Lectures required
Unit	Particulars	
01	Fundamentals: Classical and quantum computers principals; Probability; Statistics; Matrices; Advantages of quantum computation; Superposition; Entanglement; Interference, Single qubit operations and measurements;	10
02	Quantum Cryptography: Classical and Quantum Cryptography; Physical implementations.Entanglement: Entangled states; Bells inequality; von-Neumann entropy; Quantification of pure state entanglement. Mixed state entanglement; quantification of mixed state entanglement Concurrence.	10
03	Quantum Algorithms and Computation: Quantum no-cloning; The Deutsch-Jozsa algorithm; Quantum simulations; Quantum logic gates and circuits; Universal quantum gates; Quantum Fourier Transform; Phase Estimation; Shor's algorithm; Grovers algorithm; Quantum phase estimation. Decoherence and Quantum Error Correction: Decoherence; Errors in quantum computation and communication; Quantum error correcting codes; Elementary discussion of entanglement concentration and distillation.	10

Recommended Books		
Sr. No.	Text Book	Author
01	Quantum Computation and Quantum information,	Nielsen and Chuang, Cambridge University Press, 2010

Subject: Defects in Solid State Physics **Course Code: PSPHY EL6**	Year & Semester: M.Sc. Physics 2nd Year & 3rd Semester.		Credit 3, L 3, T 0, P 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	To understand the origin and nature of defects in crystals
CO2	To identify the importance of defects
CO3	To identify the fundamental knowledge of various methods and techniques for the defect analysis
CO4	To explore the influence of the defects on macroscopic properties and process

Course contents		Lectures required
Unit	Particulars	
01	Thermodynamic parameters: energy, volume and entropy of formation of point defects. Theory of thermal activation of atoms. Vineyard theory. Equilibrium concentration of thermal defects. Contribution to thermodynamical properties. Ionic conduction via point defects: illustration for specific mechanisms. Electrical conductivity of doped crystals and elucidation of the mechanisms of charge transport. Theory of impurity-vacancy association. Long range interactions: Debye-Lidiard theory. High temperature anomalies. Analysis of conductivity.	10
02	Dielectric relaxation due to point defects. Relaxation mechanisms. Ionic Thermocurrent Technique. Anelasticity, internal friction and mechanical resonance. Point defects in metals and semiconductors: Electrical resistivity, specific heat and thermal expansion techniques of measuring defect parameters. Direct methods of study field ion microscopy, tunneling microscopy.	10
03	Color centers: mechanisms of production by various methods. Optical and magnetic properties. Models and physical properties: absorption, luminescence, photoconductivity and magnetism. Color center lasers. Theory of localized states in crystals. Calculation of thermodynamic parameters of point defects. Dislocations. Plastic deformation. Dislocation models. Elastic fields around edge and screw dislocations. Energy of a dislocation. Interactions between dislocations and between line defects and point defects. Role of dislocations in crystal growth. Mechanisms of hardening. Methods of studying dislocations.	10

Recommended Books		
Sr. No.	Text Book	Author
01	Defects and Diffusion in Solids -An Introduction, Elsevier Scientific (1980).	S Mrowec
	Reference Books	
01	Physics of Defects, North Holland (1980)	J.P. Poirier,
02	Theory of Defects in Solids, Oxford University Press (1985).	A.M. Stoneham
03	Point Defects and Diffusion, Clarendon Press (1972)	C.P. Flyn

Subject: Photovoltaic Systems **Course Code: PSPHY EL7**	Year & Semester: M.Sc. Physics 2nd Year & 3rd Semester.		Credit: 3, L: 3, T: 0, P: 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	Students will gain an understanding of the available solar energy and the current solar energy conversion and utilization processes.
CO2	Students will able to comprehend the challenges in sustainable energy processes, perform cost analysis, design photovoltaic systems for different applications meeting residential and industrial needs, predict and test performance.
CO3	Students will gain an insight of the photovoltaic system engineering aspects including modeling and upscaling of the PV systems with different approaches, and be able to advance photovoltaic systems.
CO4	Students will be able to evaluate difference between Hybrid organic, Inorganic solar cells, multi-junction solar cells etc

Course contents		Lectures required
Unit	Particulars	
01	Human and World energy consumption, Method of energy conversion, Need for sustainable energy sources, Limited fossil fuel, Renewable energy sources, Current status of wind energy, Solar thermal, Biomass and Hydroelectricity, Sustainable Sun energy, Solar radiation, Black body radiation, Terrestrial solar radiation, Solar spectrum, A brief review of different types of solar cells in the market.	10
02	Photoelectric effect, Photoconductivity, Photo emissive effect and photovoltaic effect, A comparison, Working principle of solar cells, Generation of charge carriers, Separation and collection solar cell parameters, Equivalent circuit, External solar cell parameters, External quantum efficiency and Equivalent circuit. The thermodynamic limit, Shockley-Quiesser limit, Losses in Solar cell design, Design for high Isc, High Voc, High FF. Analytical techniques, Solar simulator, Quantum efficiency measurement minority carrier life time and diffusion length measurement.	10
03	Silicon wafer based solar cell, basic silicon solar cell, Strategies to enhance Absorption, reduce surface recombination, reduce series resistance, thin film solar cells, Transparent conducting oxides, Chalcogenide solar cells, Organic photovoltaics, Perovskite, Dye sensitized solar cells, Hybrid organic, Inorganic solar cells, multi-junction solar cells, Spectral conversion, Multi exciton generation, Photovoltaic system Design	10

Recommended Books		
Sr. No.	Text Book	Author
01	Solar Photovoltaics, Fundamentals, Technologies and applications, PHI Learning, 2011.	Chetan Singh Solanki,
	Reference Books	
02	Solar Energy Fundamentals, Technology and Systems, Delft University of Technology (2014).	Klaus Jäger, Olindo Isabella, Arno H.M. Smets, René A.C.M.M. van SwaaijMiroZeman,
03	The Physics of Solar Cells, Imperial College Press (2013).	Jenny Nelson

Subject: Laboratory for Characterization of materials **Course Code: PSPHY LB5**	Year & Semester: M.Sc. Physics 2nd year & 3rd Semester.		Credit 2, L 0, T 0, P 4
Evaluation Policy	Mid-Term	Class Assessment	End-Term
		10 Marks	90 Marks

Credit	L	T	P
2	0	0	4

Sr. No.	Course outcomes
CO1	Develop understanding of principles of various characterization instruments
CO2	Analyze working of XRD, SEM, UV Visible Spectrometer.
CO3	Students will learn X-ray Diffractometry, SEM and Spectroscopic techniques
CO4	Calculate and interpret results

List of Experiments

Experiment No 1: Phase identification of an unknown sample by X-ray diffraction spectroscopy.
Experiment No 2: Determination of Miller indices, space group, lattice parameters and unit cell volume of an unknown powder crystalline material by X-ray diffraction technique.
Experiment No 3: To carry out Williamson Hall plot analysis of X-ray diffraction data to estimate the strain and grain size for given samples.
Experiment No 4: To carry out X-ray diffraction measurements on single crystalline substrate (R-cut Sapphire, C-cut sapphire crystalline quartz).
Experiment No 5: To determine of Lattice parameters, particles sizes etc. of different powder samples of bulk-/nano-systems (ferrite, α-Fe_2O_3, γ-Fe_2O_3) using X-ray diffractograms.
Experiment No 6: To determine the particle size and lattice strain of an unknown powder specimen using Origin software and Scherrer equation.
Experiment No 7: To study the porosity and grain size of thin film and powder samples by Scanning Electron Microscopy.
Experiment No 8: To study microstructure of pure metals.
Experiment No 9: Spectroscopy Experiments.
(a)- UV Visible
(b)- Photoluminescence
(c)- Raman

Recommended Text Books

Sr. No.	Name of the book	Author
01	Elements of X-ray Diffraction	B.D Cullity
02	Material characterization Techniques	S. Zhang, L. Li&A. Kumar
03	Material characterization: Introduction to Microscopic and spectroscopic Methods	Yang Leng
04	Nanotechnology	MA Shah & Tokeer

Subject : Electronics Tinkering Lab **Course Code: PSPHY LB6**	Year & Semester: M.Sc. Physics 2nd year & 3rd Semester.		Credit: 2 / L: 0 / T: 0 / P: 4
Evaluation Policy	Mid-Term	Class Assessment	End-Term
		10 Marks	90 Marks

Sr. No.	Course outcomes
CO1	The course aims through a theoretical and experimental approach to give fundamental insights into solid state physics.
CO2	The candidate should know about: p-n junction diodes and transistors
CO3	Students will be understanding the principle of Solar cell and working.
CO4	With the help of ExpEYES-17 kit students will be able to make circuit on breadboard using theoretical knowledge.

List of Experiments

Experiment No. 1 Study of characteristics of semiconductor diode.
Experiment No. 2 Study of P-N junction with temperature.
Experiment No. 3: Investigation of transistor characteristics of n-p-n and p-n-p transistors
Experiment No. 4: To determine the h-parameters of a transistor.
Experiment No. 5 To plot the V-I Characteristics of the solar cell and hence determine the fill factor
Experiment No. 6: To study the Schmitt trigger characteristic using IC 741
Experiment by EXPEYES-17 kit
Title of experiments:

Half wave Rectifier | Full wave Rectifier | Diode Clipping
Diode Clamping | Diode Characteristics | Transistor Amplifier
Inverting Amplifier | Non-inverting Amplifier | Logic Gate

Recommended Text Books

Sr. No.	Name of the book	Author
01	Digital Principles and Applications, (McGraw-Hill Education)	D. P. Leach, A. P. Malvino
02	Digital Fundamentals:	Floyd & Jain (Pearson Education)
03	EXP EYES- 17 Kit Manual	Manual, PHDENIX Project, IUAC, New Delhi

SEMESTER – IV

S.	Course Code	Courses	L	T	P	Credits
1.	PSPHY PR1	Research Based Project (Full Semester)	0	0	32	**16**
	Total					**16**

Subject Research Based Project (Full semester) Course Code: PSPHY PR1	Year & Semester: M.Sc. Physics 2nd year &4th Semester		Credit 16	L 0	T 0	P
Evaluation Policy	Mid-Term	Class Assessment	End-Term			
	30 marks	10 Marks	60 Marks			

Course contents	
Unit	Particulars
	Guidelines for Project in M.Sc. Course: 1. Projects would be allotted to M.Sc. (Previous) students which have to be carried out and completed in M.Sc. (Final). 2. A list of projects will be finalized and announced by the Department. The students will have an option to select the project in their field of interest. 3. The project will comprise of the following: a. Collection of data, procurement and fabrication of experimental set up and writing of computer programs if needed. b. Writing a dissertation or project report. This will be submitted by the M.Sc. (Final) students in the first week of May. c. Giving a preliminary seminar before the final presentation for the purpose of internal assessment whose weight age would be 25%. 4. The Final evaluation of the project work completed will be done by external and internal examiners appointed by the Board of Studies on the basis of an oral presentation and the submitted Project-Report. 5. The weight age of the final evaluation would be 75%.

Recommended Text Books		
Sr. No.	Name of the book	Author

Evaluation Scheme

Supervisor	HOD/Nominee HOD	Member from sister department	External	Total
50	20	10	20	100

ELECTIVES

(A) List of Departmental Electives for M.sc/ Pre Ph.D.-Course Work/Electives for other Departments (OPEN)

S. No.	Course Code	Courses	L	T	P	Credits
1.	**PSPHY ELC**	**Research Methodology (Core Course)**	**3**	**0**	**0**	**3**
2.	PSPHY ELR1	General Theory of Relativity and Cosmology	3	0	0	3
3.	PSPHY ELR2	Nano-Biomaterials, Biosensors and Applications	3	0	0	3
4.	PSPHY ELR3	Superconductivity and Low Temperature Physics	3	0	0	3
5.	PSPHY ELR4	Nano-Fabrication of Materials	3	0	0	3
6.	PSPHY ELR5	Principles of Lasers and Fiber Optics	3	0	0	3
7.	PSPHY ELR6	Functional Materials and Applications	3	0	0	3
8.	PSPHY ELR7	Quantum Field Theory	3	0	0	3
9.	PSPHY ELR8	Python Programming and Introduction to Data Science	3	0	0	3
10.	PSPHY ELR9	Spin-electronics and applications	3	0	0	3
11.	PSPHY ELR10	Advanced Condensed Matter Physics	3	0	0	3
12.	PSPHY ELR11	Characterizations Techniques of Materials	3	0	0	3
13.	PSPHY ELR12	Group Theory for Physicists	3	0	0	3
14	PSPHY ELR13	Machine Learning/Artificial intelligence	3	0	0	3
15	PSPHY ELR14	Medical Physics	3	0	0	3

Physics Department is First to adopt Curriculum as per NEP 2020

Subject Research Methodology Course Code: PSPHY ELC	Year & Semester: M.Sc./ Pre Ph.D. Open		Credit 3, L 3, T 0, P 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	The student should be well versed to take a research problem for his/her master's or doctoral research. They will understand the nuances of scientific writing and IPR.
CO2	Students will learn data collection and data preparation
CO3	Students will learn data classification, Thesis writing
CO4	Students will learn to interpret data

Course contents		Lectures required
Unit	Particulars	
01	Research Methodology Meaning of research, Objectives of research, Types of research, Research approaches, Significances of research, Research methods versus methodology, Research and scientific methods, Research processes, Criteria for good research, Research problem, Selecting the problem, Necessity of defining the problem	10
02	Research Design and sample Surveys Meaning and need for research design, features of a good design. Important concepts relating to research design: Dependent and independent variables, Extraneous variables, Control, Research hypothesis, Experimental and non-experimental hypothesis – Testing research, Experimental and control group, Different research designs: Research design in case of exploratory research studies, Research design in case of hypothesis- testing research studies.	10
03	Data Collection and Data Preparation Experiments and surveys, Collection of primary data: Difference between questionnaire and schedule, Guidelines for constructing questionnaire/schedule, Collection of secondary data, Selection of appropriate methods for data collection, Case study method. Data preparation process: Questionnaire checking, Editing, Coding, Classification, Tabulation, Graphical representation, Data cleaning, Data adjustment, Types of analysis, Statistics in research. Interpretation and Report Writing Meaning of Interpretation, Technique of Interpretation, Precautions in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of Research Report, Types of Reports, oral Presentation, Mechanics of Writing Research Report, Precautions for writing Research reports.	10

Recommended Books		
Sr. No.	Text Book	Author
01	The Craft of Scientific Writing (3rd Edition),	Michael Alley, Springer, New York, 1996.
	Reference Books	
01	Science and Technical Writing – A Manual of Style (2nd Edition),	Philip Reubens (General editor), Routledge, New York, 2001

Subject: General Theory of Relativity and Cosmology **Course Code: PSPHY ELR1**	Year & Semester: M.Sc./ Pre Ph.D. Open		Credit 3	L 3	T 0	P 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term			
	30 Marks	10 Marks	60 Marks			

Sr. No.	Course outcomes
CO1	Introduce the theoretical framework and experimental necessity of Einstein theory of general relativity;
CO2	Understand the principles of general relativity and physics in curved spacetime
CO3	Develop tools to enable the quantitative calculation of general relativistic effects
CO4	Provide a foundation for more advanced studies of general relativity

Course contents		Lectures required
Unit	Particulars	
01	Riemannian Geometry: Vectors and Tensors; parallel transport, covariant differentiation; Geodesics; Riemann-Christoffel curvature tensor - its symmetry properties, Ricci tensor; Bianchi identities; vanishing of the curvature tensor as a condition for flatness, Geodesic deviation equation. Principle of general covariance and principle of equivalence; Einstein field equations, derivation from a variational principle	10
02	Schwarzschild exterior solution, Birkhoff's theorem. Geodesics in a Schwarzschild geometry. Crucial tests of general relativity - perihelion shift, bending of light, gravitational redshift. Schwarzschild blackhole - event horizon and static limit, Kruskal - Szekere's diagram	10
03	Cosmological Models: Universe at large scales – Homogeneity and isotropy – distance ladder– Newtonian cosmology - expansion and redshift - Cosmological Principle - Hubble's law -Robertson-Walker metric - Observable quantities – luminosity and angular diameter distances- Horizon distance- Dynamics of Friedman- Robertson-Walker models: Friedmann equations for sources with p=wu and w =−1, 0, 1/3, discussion of closed, open and flat Universes.	10

Recommended Books		
Sr. No.	Text Book	Author
01	Lecture on General Relativity and Cosmology, The Macmillan Company of India Limited.	J. V. Narlikar,
	Reference Books	
01	Introduction to General Relativity, McGraw-Hill.	R. Adler, M. Bazin and M. Schiffer,
02	Cosmological Physics, Cambridge University Press,	J . A. Peacock
03	Introduction to Cosmology, Cambridge University Press, 1993 (For the lectures on Cosmology).	J. V. Narlikar,

Subject: Nano-Biomaterials , Biosensors and Applications **Course Code: PSPHY ELR2**	Year & Semester: M.Sc./ Pre Ph.D. Open		Credit	L	T	P
			3	3	0	0
Evaluation Policy	Mid-Term	Class Assessment	End-Term			
	30 Marks	10 Marks	60 Marks			

Sr. No.	Course outcomes
CO1	Understand basic properties of nanoparticles and biomaterials
CO2	Understand the various methods for synthesis of nano-biomaterials
CO3	Understand the various characterization techniques of nano-biomaterials
CO4	Understand application of nano-biomaterials with novel optical behaviour

Course contents		Lectures required
Unit	Particulars	
01	Introduction to nano biomaterials; development of nano biomaterials (current applications, nanostructured materials used in pharmaceutical/biomedical applications	10
02	Micro-, meso- and macroporous structures; nanostructured surfaces; examples of polymeric, metallic, inorganic, hybrid and composite nano biomaterials preparation	10
03	Functionalization/bioconjugation of nano biomaterials, biosensors; smart and stimuli-responsive nano biomaterials	10

Recommended Books		
Sr. No.	Text Book	Author
01	Biomaterials: An Introduction	Park, Joon, Lakes, R. S.
	Reference Books	
01	Nano biomaterials. Development and Applications	Kee Yi, D. Papaefthymiou, G.C.,
02	Nano biomaterials. Classification, Fabrication and Biomedical Applications	Wang, X., Ramalingam, M., Kong, X., Zhao, L.

Subject: Superconductivity and Low Temperature Physics **Course Code: PSPHY ELR3**	Year & Semester: M.Sc./ Pre Ph.D.-Physics		Credit: 3	L: 3, T: 0, P: 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term	
	30 Marks	10 Marks	60 Marks	

Sr. No.	Course outcomes
CO1	Develop understanding of basic concepts in superconductivity
CO2	Analyze types of superconductors and its applications
CO3	Understand basic concepts in low temperatures
CO4	Analyse different techniques to achieve low temperatures

Course contents		Lectures required
Unit	Particulars	
01	Survey of Superconductivity, Perfect Conductivity, Magnetoquasistatics, London's Equations, Classical Model of a Superconductor, Electromagnetic Power, Transmission Lines, Perfect Diamagnetism, Macroscopic Quantum Model, Supercurrent Equation.	10
02	Basic Josephson Junctions, SQUID, Generalized Josephson Junctions, Josephson Circuits Type II Superconductors and Critical Fields, Flux Flow, Pinning, Ginzburg-Landau Theory, Microscopic Interactions and Cooper Problem, BCS I, BCS II, Quantum Circuits I, Quantum Circuits II, Quantum Tunneling Devices and Detectors	10
03	Thermodynamics of different refrigeration processes, liquefaction of gases; methods to reach low (< 1 Kelvin) temperatures: evaporation cooling, He-3,He-4 dilution cooling, Pomeranchuk effect, adiabatic demagnetization of atoms and nuclei; Thermometry at low temperatures (e.g.,helium, magnetic thermometry, noise thermometry, thermometry using radioactive nuclei); principles for the construction of cryostats for low temperatures	10

Recommended Books		
Sr. No.	Text Book	Author
01	Introduction to superconductivity	A C Rose Innes.
02	Superconductivity	Stephen Blundell

Subject: Nano Fabrication of Materials **Course Code: PSPHY ELR4**	Year & Semester: M.Sc./ Pre-Ph.D. Physics	Credit: 3	L: 3	T: 0	P: 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term		
	30 Marks	10 Marks	60 Marks		

Sr. No.	Course outcomes
CO1	The students will be exposed to various structure specific synthesis methods, their advantages etc.
CO2	To know about Top-down to Bottom-up approach techniques.
CO3	To be able to explain the production of characteristic X-rays.
CO4	The students will be able to calculate shape and size of nanomaterials. The students will be able to understand structural, optical and morphological properties of nanomaterial.

Course contents		Lectures required
Unit	Particulars	
01	Chemical Method Sol-Gel synthesis, Chemical Bath Deposition; Hydrothermal, Auto combustion methods. Ball-milling, Microwave assisted synthesis Core-Shell nanostructure, Quantum dot (QDs) synthesis, Sonochemical and Electrochemical synthesis	10
02	Physical Method Physical vapor deposition (PVD), Chemical vapor deposition (CVD), Inert gas condensation, RF-plasma, Micro wave plasma, Ion sputtering, laser ablation, laser pyrolysis, molecular beam epitaxy, electro-deposition.	10
03	Diffraction analyses: X-ray diffraction, powder diffraction, lattice parameters, structure analyses, strain analyses, phase identification, particle size analyses. Surface Imaging: Scanning Electron Microscope Atomic Force Microscopy Transmission Electron Microscopy. Spectroscopic techniques: Infra-red spectroscopy, Rotational & Vibrational, UV-visible – NIR, Raman Spectroscopy, Photoluminescence, Cathodoluminescence.	10

Recommended Books		
Sr. No.	Text Book	Author
01	The Chemistry of nanomaterials: Synthesis, Properties and Applications	C.N.R. Rao,
	Reference Books	
02	Transmission Electron Microscopy, Springer, 2nd Edition,	David B. Williams & C.B Carter,

<table>
<tr><td colspan="2">Subject: Principles of Lasers & Fiber Optics
Course Code: PSPHY ELR5</td><td colspan="2">Year & Semester: M.Sc./ Pre Ph.D.-Physics</td><td>Credit: 3
L: 3
T: 0
P: 0</td></tr>
<tr><td colspan="2" rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td>End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td>60 Marks</td></tr>
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Sr. No.	Course outcomes
CO1	Students will understand basics fundamentals of lasers.
CO2	Students will be able to apply knowledge about lasers in Industrial applications.
CO3	Students will understand basics of optical fibers.
CO4	Students will learnabout Fabrication of optical fibres.

Course contents		Lectures required
Unit	Particulars	
01	Laser Fundamentals Fundamental wave properties and quantum properties of light, Energy levels and Radiative properties, Absorption and Stimulated Emission, Laser Amplifiers, Laser Oscillation above threshold, Requirements for obtaining Population Inversion, Laser pumping requirements and techniques, Laser Resonators, Cavity modes, Laser interaction with tissue- Effects and principles, Thermal interaction between laser and tissue.	10
02	Laser pumping requirements and techniques, Laser Resonators, Cavity modes, Laser interaction with tissue- Effects and principles, Thermal interaction between laser and tissue.	10
03	Optic Fibers Fundamentals Light transmission in optical fibers- principles, optical properties of optical fibers, Fiber materials, Types of Optical fibers, Modes, Losses, Fabrication of optical fibers, Methods and Principle, Fiber Splicing, Fiber optic imaging, Biomedical Optical fibers, In vivo Applications. Fabrication of optical fibers, Methods and Principle, Fiber Splicing, Fiber optic imaging, Biomedical Optical fibers, In vivo Applications.	10

Recommended Books		
Sr. No.	Text Book	Author
01	Therapeutic Lasers	G David Baxter
	Reference Books	
02	Medical Laser and their safe use	David H Shiny Stiffen and L Trokel
03	Lasers in Medicine, Volume-1	Hans K. Koebner
04	Element of Fiber optics	S. L. Wymer Regents

Subject: Functional Materials and Applications **Course Code: Physics ELR6**	Year & Semester: M.Sc./ Pre Ph.D.-Physics		Credit: 3, L: 3, T: 0, P: 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	Develop idea about functional materials
CO2	Develop idea about optoelectronic materials
CO3	Will understand different properties of materials and how to tailor these properties
CO4	Students will be able to understand formation of domain walls.

Course contents		Lectures required
Unit	Particulars	
01	Introduction: Useoffunctionalitiesofmaterialsinfabricatingdevices,Functionality arising due to (i) electronic, (ii) spin, and (iii)ionic degrees of freedom; Exploitation of combined effects in designing new functionalmaterials.	10
02	Functionality driven by electronic degrees of freedom: Formation of bands in crystalline solids;Band dispersions; Density of states; Metals, semiconductors and insulators; Direct andindirect band gap semiconductors; Electrons effective massin a semiconductor; Transport and opticalpropertiesof asemiconductor;Opto-electronicmaterials.	10
03	Functionality driven by spin degrees of freedom: Formation of magnetic moment inan atom; Spin and orbital part of magnetic moment in a solid; Magnetization of a solid;Diamagnetic, paramagnetic, ferromagnetic and antiferromagnetic materials; Differentkind of antiferromagnetic structures; Exchange interaction;	10

Recommended Books		
Sr. No.	Text Book	Author
01	ThePhysicsofSemiconductors:AnIntroductionIncludingDevicesandNanophysics	Marius Grundmann, Springer Berlin Heidelberg NewYork
	Reference Books	
01	Electronic Structure :Basic Theory and Practical Methods	R.M .Martin, Cambridge University Press

Subject: Quantum Field Theory **Course Code: PSPHY ELR 7**	Year & Semester: M.Sc./ Pre Ph.D.-Physics		Credit 3, L 3, T 0, P 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Credit	L	T	P
3	3	0	0

Sr. No.	Course outcomes
CO1	Quantize classical fields and will know how to describe both fermionic and bosonic particles in relativistic quantum mechanics
CO2	Derive the Feynman rules for a given theory, and how to use those to calculate cross sections and decay rates at lowest order in perturbation theory.
CO3	Explain how gauge symmetries lead to the construction of both Abelian and non-Abelian theories and understand the concept of spontaneously breaking these symmetries (Higgs mechanism)
CO4	Understand the structure of the standard model of particle physics and can relate its ingredients to the underlying fundamental principles

Course contents		Lectures required
Unit	Particulars	
01	Relativistic Wave Equations: Klein-Gordon equation. Dirac equation, SU(2) and the rotation group; SL(2,C) and the Lorentz group. Prediction of antiparticles. Non-relativistic limit and Electron magnetic moment. Construction of Dirac spinors: algebra of γ- matrices. Lagrangian formulation and Noether's theorem.	10
02	Canonical quantization and particle interpretation: The real Klein-Gordon field. The complex Klein-Gordon field. The Dirac field. The electromagnetic field. Radiation gauge quantization. Lorentz gauge quantization. PCT symmetries, Symmetry Breaking and Higgs Mechanism.	10
03	The S-matrix expansion: Examples of interactions , Evolution operator, S-matrix. Wick's theorem. Feynman diagrams and Rules: Yukawa interaction: decay of a scalar. Cross section for QED processes: Electron-electron scattering. Consequence of gauge invariance. Compton scattering, Scattering by an external field. Bremsstrahlung.	10

Recommended Books		
Sr. No.	Text Book	Author
01	An Introduction to Quantum Field Theory	M. Peskin and D. V. Schroeder
	Reference Books	
01	Quantum Field theory: From Operators to Path Integrals, 2nd edition	Kerson Huang
02	Quantum Field Theory	Mark Srednicki
03	Quantum Field Theory	Claude Itzykson and Jean Bernard Zuber

Subject: Python Programming and Introduction to Data Science **Course Code: PSPHY ELR 8**	Year & Semester: M.Sc./ Pre Ph.D.-Physics		Credit: 3, L: 3, T: 0, P: 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	Develop fundamentals of programming
CO2	Construct scripts to solve problems
CO3	Analyze scripts to remove bugs
CO4	Develop fundamentals of data science

Course contents		Lectures required
Unit	Particulars	
01	What is computation, Branching and Iteration, String Manipulation, Guess and Check, Approximations, Bisection, Decomposition, Abstractions,	10
02	Functions, Tuples, Lists, Aliasing, Mutability, Cloning, Recursion, Dictionaries, Testing, Debugging, Exceptions, Assertions, Object Oriented Programming, Understanding Program Efficiency, Searching and Sorting,	10
03	Numerical integration and differentiation, ODE solvers, Fourier transform, PDE solvers, Diffusion equation and Wave equation, Schrodinger Equation, Data Processing and Data Visualization using Matplotlib and Pandas	10

Recommended Books		
Sr. No.	Text Book	Author
01	Python Crash Course, 2nd Edition: A Hands-On, Project-Based Introduction to Programming	Eric Matthes
	Reference Books	
01	PYTHON DATA SCIENCE HANDBOOK: Essential Tools for Working with Data	Jake Vander Plas

Subject: Spin- Electronics and Applications **Course Code: PSPHY ELR 9**	Year & Semester: M.Sc./ Pre Ph.D.-Physics .		Credit 3 / L 3 / T 0 / P 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Credit	L	T	P
3	3	0	0

Sr. No.	Course outcomes
CO1	Develop fundamentals of spin electronics
CO2	Understand different concepts related to utilization of spin in electronics
CO3	Analyze different materials for spin based electronic devices
CO4	Analyze different electronic devices based on spin

Course contents		Lectures required
Unit	Particulars	
01	Exchange interaction; Spin relaxation mechanisms; spin relaxation in a quantum dots; The spin Galvanic effect; Basic electron transport; Spin-dependent transport; Spin dependent tunneling; Andreev Reflection at ferromagnet and Superconductor interfaces;	10
02	Spin transfer torques; Spin-transfer drive magnetic dynamics; Current-driven switching of magnetization and domain wall motion; Domain wall scattering and Current Induced switching in ferromagnetic wires; Spin injection, spin accumulation, and spin current,	10
03	Spin hall effect, Silicon based spin electronic devices, Spin LEDs: Fundamental and applications, Spin photoelectronic devices based on Heusler alloy, Electron spin filtering, Materials for spin electronics, Nanostructures for spin electronics, Deposition techniques, micro and nanofabrication techniques. Spin-Valve and spin-tunneling devices: Read Heads, MRAMS, Field Sensors, Spintronic Biosensors, Spin transistors, Quantum Computing with spins. Motion as a stochastic process; Basic ideas behind the Fokker-Planck, fluctuation-dissipation theorem	10

Recommended Books		
Sr. No.	Text Book	Author
01	Fundamentals of Nanoelectronics” Pearson Education	George W. Hanson,
	Reference Books	
01	“Introduction to Nanoelectronics Science, Nanotechnology, Engineering and Applications” Cambridge University Press.	Vladmir V. Mitin et al
02	Lessons from Nanoelectronics, A New Perspective on Transport	Supriyo Dutta (Purdue University)

Subject: Advanced Condensed Matter Physics **Course Code: PSPHY ELR 10**	Year & Semester: M.Sc./ Pre Ph.D.-Physics		Credit: 3, L: 3, T: 0, P: 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	Students will understand Magnetoresistance of materials.
CO2	Students will evaluate Spin Waves and Heisenberg Hamiltonian.
CO3	Students will understand about Ferroelectricity
CO4	Students will understand Cherenkov Radiation, Energy Loss of Electrons and Positrons

Course contents		Lectures required
Unit	Particulars	
01	TRANSPORT PHENOMENON IN MAGNETIC FIELD: Boltzmann Transport Equation In Magnetic Field, Magnetoconductivity, Introduction to Magnetoresistance (MR), Transport Equations for Magnetoresistance, Lorentz MR, Anisotropic MR, Spin-Disorder MR And Colossal MR, Giant MR, Tunnel MR, Other Magneto resistive Effects, Applications of Magneto resistive Devices, The Variation Principle in Magnetic Field, Numerical Problems.	10
02	SPIN AND ORBITAL MAGNETISM: Simplification of Hamiltonian, Second Quantized form of Hamiltonian, Spin Waves and Heisenberg Hamiltonian, Linear Chain with Ferromagnetic Interaction, Spontaneous Magnetization, Antiferromagnetism-Spin Wave Theory, Physical Picture, Variational Calculation of Ground State, Sub-Lattice Magnetization, Numerical Problems.	10
03	DIELECTRICS & FERROELECTRICS: Structural Phase Transition, Ferroelectric Crystals, Displacive Transitions, landau Theory of the Phase Transition, first and second Order Phase Transitions ION BEAMS IN SOLIDS: Energy Loss of Heavy Charged Particles by Atomic Collisions, Cherenkov Radiation, Energy Loss of Electrons and Positrons, Energy Loss by High Energy Ion: Inelastic Collision- Electronic Energy Loss, Elastic Collision-Nuclear Energy Loss. Multiple Coulomb Scattering, Energy Loss Distribution, Swift Heavy Ion Irradiation: Pelletron Accelerator, Material Science Beam Line, Ion Solid Interaction, Thermals Spike Model, Coulomb Explosion Model, Point Defects , Numerical Problems.	10

Recommended Books		
Sr. No.	Text Book	Author
01	Introduction to Solid State physics	Charles Kittle, 8th edition, (Wiley Eastern Ltd.).
	Reference Books	
01	Principles of Condensed Matter Physics	P.M. Chaikin and T.C.Lubensky.
02	Solid State Physics	A. J. Dekker, Macmillan, New Ed)
03	Modern Electron Instrumentation and Measurement Techniques	A.D. Helfrick and W.D.Cooper:

Syllabus formulated during Week Long Curriculum Development Workshop (25-29 July 2022)

Subject: Characterizations Techniques of Materials **Course Code: PSPHY ELR 11**	Year & Semester: M.Sc./ Pre Ph.D. Physics		Credit: 3, L: 3, T: 0, P: 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	Students will learn about X-ray diffraction: phase identification, transmission electron microscopy
CO2	Students will understand Differential thermal analysis (DTA), Differential Scanning Calorimetry.
CO3	Students will understand , Nuclear Magnetic Resonance, Electron Spin Resonance;
CO4	Students will learn UV-VIS spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy, X-ray photoelectron spectroscopy.

Course contents		Lectures required
Unit	Particulars	
01	Structure analysis tools: X-ray diffraction: phase identification, indexing and lattice parameter determination, Analytical line profile fitting using various models, Neutron diffraction, Reflection High Energy Electron Diffraction, and Low Energy Electron Diffraction; Microscopy techniques: Optical microscopy, transmission electron microscopy (TEM), energy dispersive X-ray microanalysis (EDS), scanning electron microscopy (SEM), Rutherford backscattering spectrometry (RBS), atomic force microscopy (AFM) and scanning probe microscopy (SPM)	10
02	Thermal analysis technique: Differential thermal analysis (DTA), Differential Scanning Calorimetry (DSC), Thermogravimetric analysis (TGA); Electrical characterization techniques: Electrical resistivity in bulk and thin films, Hall effect, Magnetoresistance.	10
03	Magnetic characterization techniques: Measurement Methods, Measuring Magnetization by Force, Measuring Magnetization by Induction method, Types of measurements using magnetometers: M-H loop, temperature dependent magnetization, time dependent magnetization, Measurements using AC susceptibility, Magneto-optical Kerr effect, Nuclear Magnetic Resonance, Electron Spin Resonance; Optical and electronic characterization techniques: UV-VIS spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy, X-ray photoelectron spectroscopy.	10

Recommended Books		
Sr. No.	Text Book	Author
01	Materials Characterization Techniques,	S Zhang, L. Li and Ashok Kumar, CRC Press (2008).
	Reference Books	
01	Semiconductor Material and Device Characterization, 3rd Edition,	D.K.Schroder, Wiley-IEEE Press (2006).
02	Physical methods for Materials Characterization	P.E. J. Flewitt and R K Wild, IOP Publishing (2003).
03	Characterization of Nanophase materials,	Wang, Willet-VCH (2000).

Subject: Group Theory for Physicists. Course Code: PSPHY ELR12	Year & Semester: M.Sc./ Pre Ph.D.-Physics		Credit: 3, L: 3, T: 0, P: 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	Students will learn about Lagrange's theorem, invariant subgroup, Homomorphism and isomorphism between two groups
CO2	Students will understand Infinitesimal generators, Lie algebra
CO3	Students will understand , Special Unitary Groups
CO4	Students will be understand SU(3) symmetry in elementary particle physics.

Course contents		Lectures required
Unit	Particulars	
01	DISCRETE GROUPS: Definition of a group, subgroup, class, Lagrange's theorem, invariant subgroup, Homomorphism and isomorphism between two groups. Representation of a group, unitary representations, reducible and irreducible representations Schur's lemmas, orthogonality theorem, character table, reduction of Kronecker product of representations, criterion for irreducibility of a representation.	10
02	CONTINUOUS GROUPS: Infinitesimal generators, Lie algebra; Rotation group, representations of the Lie algebra of the rotation group, representation of the rotation group, D-matrices and their basic properties. Addition of two angular momenta and C.G. coefficients, Wigner-Eckart theorem.	10
03	SPECIAL UNITARY GROUPS: Definition of unitary, unimodular groups SU(2) and SU(3). Lie algebra of SU(2). Relation between SU(2) and rotation group. Lie algebra of SU(3)-Gellman's matrices. Cartan form of the SU(3). Lie algebra, roots and root diagram for SU(3). Weights and their properties, weight diagrams for the irreducible representations 3.3*-, 6,6 8, 10 and 10 of SU(3). Direct product of two SU(3) representations, Young tableaux method of decomposition of products of IR's illustrations with the representations of dim <10 C.G. coefficients for 3 x 3* and 3 x 6 representations. SU(3) symmetry in elementary particle physics, quantum numbers of hadrons and SU(2) and SU(3) classification of hadrons.	10

Recommended Books		
Sr. No.	Text Book	Author
01	Group Theory for Physicists	A.W.Joshi
	Reference Books	
01	Unitary Symmetry and Elementary Particles	D.B.Lichtenberg,
02	Mathematical Physics	E.Butkov,

Subject: Artificial Intelligence/Machine Learning **Course Code: PSPHY ELR 13**	Year & Semester: M.Sc./ Pre Ph.D.- Physics		**Credit** **3**	**L** **3**	**T** **0**	**P** **0**
Evaluation Policy	Mid-Term	Class Assessment	End-Term			
	30 Marks	10 Marks	60 Marks			

Sr. No.	Course outcomes
CO1	To learn the difference between optimal reasoning Vs human like reasoning
CO2	To understand the notions of state space representation, exhaustive search, heuristic search along with the time and space complexities
CO3	To learn different knowledge representation techniques
CO4	To understand the applications of AI: namely Game Playing, Theorem Proving, Expert Systems, Machine Learning and Natural Language Processing

Course contents		Lectures required
Unit	Particulars	
01	Introduction: What is AI? , History, Overview, Intelligent Agents, Performance Measure, Rationality, Structure of Agents, Problem solving agents, Problem Formulation, Uninformed Search Strategies. Informed (Heuristic) Search and Exploration, Greedy best first search, A* search, Memory bounded heuristic search, Heuristic functions, inventing admissible heuristic functions, Local Search algorithms, Hill climbing, Simulated Annealing, Genetic Algorithms, Online search	10
02	Constraint Satisfaction Problems, Backtracking Search, variable and value ordering, constraint propagation, intelligent backtracking, local search for CSPs, Adversarial Search, Games, The minimax algorithm, Alpha Beta pruning, Imperfect Real Time Decisions, Games that include an Element of Chance	10
03	Knowledge Based Agents, Logic, Propositional Logic, Inference, Equivalence, Validity and Satisfiability, Resolution, Forward and Backward Chaining, DPLL algorithm, Local search algorithms, First Order Logic, Models for first order logic, Symbols and Interpretations, Terms, Atomic sentences, complex sentences, Quantifiers, Inference in FOL, Unification and Lifting, Forward Chaining, Backward Chaining, Resolution Planning, Language of planning problems, planning with state space search, forward and backward state space search, Heuristics for state space search, partial order planning, planning graphs, planning with propositional logic.	10

Recommended Books		
Sr. No.	Text Book	Author
01	Artificial Intelligence a Modern Approach	Russel and Norvig ,Pearson Education,
	Reference Books	
01	Artificial Intelligence –	A Practical Approach : Patterson , Tata McGraw Hill, 3rd

Subject: Medical Physics **Course Code: PSPHY ELR 14**	Year & Semester: M.Sc./ Pre Ph.D.-Physics		Credit 3 / L 3 / T 0 / P 0
Evaluation Policy	Mid-Term	Class Assessment	End-Term
	30 Marks	10 Marks	60 Marks

Sr. No.	Course outcomes
CO1	Students will learn interaction of radiation with matter,
CO2	Students will understand basic dosimetry concepts and radiation detectors
CO3	Students will understand Principles of telecobalt, linear accelerator
CO4	Students will understand interaction of radiation with matter,

Course contents		Lectures required
Unit	Particulars	
01	Cells, structure and functions, Radiation sources - Natural and artificial radioactive sources ,Large scale production of isotopes, Different sources of Non-Ionizing radiation-their physical; properties	10
02	Electrical Impedance and Biological Impedance, Principle and theory of thermography its applications, Basic principles of radiation detection - Counting systems for alpha and beta radiation	10
03	Principles of Radiation detection ,properties of dosimeters, Theory of gas filled detectors, Ion chamber dosimetry systems, free air ion chamber, parallel plate chamber ,ionization chamber Laser Surgical Systems, Measurement of fluence from optical sources, Optical properties of tissues, theory and experimental techniques, interaction of laser radiation with tissues , microscopy in medicine Interaction of light (electrons and positrons) and heavy charged particles with matter ,Malignant Tumors, material response, deformation and failure ,friction and wear	10

Recommended Books		
Sr. No.	Text Book	Author
01	Laser Photobiology and Photomedicine, Plenum Press, New York, 1985	S. S. Martellucci and A. N. Chester,
	Reference Books	
01	Laser-Tissue Interactions, Springer Verlag, Germany, 1996.	Markolf H. Neimz
02	Principles of Biomedical Instrumentation and measurement, Merrill Publishing Co., London, 1990	Richad Aston,