Syllabus

For

Pre-PhD Program in Physics

Contents

List of Departmental Pre PhD Course Work

S. No.	Course Code	Courses	L	T	P	Credits
1.	PSPHD-01	Scientific Writing and IPR	3	0	0	3
2.	PSPHD-02	Functional Materials and Applications	3	0	0	3
3.	PSPHD-03	Quantum Field Theory	3	0	0	3
4.	PSPHD-04	Simulation in Material Science	3	0	0	3
5.	PSPHD-05	Group Theory for Physicists	3	0	0	3
6.	PSPHD-06	Nanoscience and Nanotechnology	3	0	0	3
7.	PSPHD-07	Characterization Techniques	3	0	0	3
8.	PS -Seminar-08	Concerned Supervisor				1

Postgraduate Department of Physics
National Institute of Technology Srinagar
(Jammu and Kashmir)

Subject: Scientific writing and IP **Course Code: PSPHD -1**	Year & Semester: Pre PhD.				Credits 3, L 3, T 0, P 0
New Education/ Evaluation Policy	Mid-Term	Class Assessment	Quiz	Attendance	End-Term
	26 Marks	8 Marks	8 Marks	8 Marks	50 Marks

Credits	L	T	P
3	3	0	0

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 and will learn to interpret data

Course contents		Lectures required
Unit	Particulars	
1	Introduction to Philosophy of Science, what is science? Scientific reasoning; Scientific Method, Explanation in science; Realism and instrumentalism; Scientific Temper. Types of research, exploratory, conclusive, modelling and algorithmic. Research process: Identification of research problems, selection of a problem, formulation of a problem. Data collection: data analysis, interpretation of results, validation of results.	10
2	Science / Scientific Writing: Types of scientific writing. Goals and Objectives, Structure of documents, importance of clear title, abstract or summary, Introduction, Methods, Results and Discussion. Illustrations and aids Numbers and statistics, Tables and Figures. Language and grammar.	10
3	Intellectual Property Rights and Associated Issues: History of Patenting, Ethics in writing, Plagiarism, paraphrasing and copy write violation. Consequences of plagiarism. Why not to fudge, tinker, fabricate or falsify data. Digitalizing Culture, Free Culture and Open Access Journals. Journals and Publishers: Monopolistic practices by Academic Publishers.	10

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

Subject: Functional Materials and Applications **Course Code: PSPHD-2**	Year & Semester: Pre Ph.D.				Credits 3, L 3, T 0, P 0
New Education/ Evaluation Policy	Mid-Term	Class Assessment	Quiz	Attendance	End-Term
	26 Marks	8 Marks	8 Marks	8 Marks	50 Marks

Credits	L	T	P
3	3	0	0

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

Course contents		Lectures required
Unit	Particulars	
1	Introduction: Use of functionalities of materials in fabricating devices, Functionality arising due to (i) electronic, (ii) spin, and (iii)ionic degrees of freedom; Exploitation of combined effects in designing new functional materials.	10
2	Functionality driven by electronic degrees of freedom: Formation of bands in crystalline solids; Band dispersions; Density of states; Metals, semiconductors and insulators; Direct and indirect band gap semiconductors; Electrons effective mass in a semiconductor; Transport and optical properties of a semiconductor; Opto-electronic materials.	10
3	Functionality driven by spin degrees of freedom: Formation of magnetic moment in an atom; Spin and orbital part of magnetic moment in a solid; Magnetization of a solid; Diamagnetic, paramagnetic, ferromagnetic and antiferromagnetic materials; Different kind of antiferromagnetic structures; Exchange interaction;	10

Recommended Books		
Sr. No.	Text Book	Author
01	The Physics of Semiconductors: An Introduction Including Devices and Nanophysics	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: PSPHD-3**	Year & Semester: Pre Ph.D.				Credits: 3, L: 3, T: 0, P: 0
New Education/ Evaluation Policy	Mid-Term	Class Assessment	Quiz	Attendance	End-Term
	26 Marks	8 Marks	8 Marks	8 Marks	50 Marks

Sr. No.	Course outcomes
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	
1	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
2	Canonical quantization and particle interpretation: The real Klein-Gordon field. The complex Klein-Gordon field. The Dirac fields. The electromagnetic field. Radiation gauge quantization. Lorentz gauge quantization. PCT symmetries, Symmetry Breaking and Higgs Mechanism.	10
3	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
1	An Introduction to Quantum Field Theory	M. Peskin and D. V. Schroeder (West View Press Inc)
	Reference Books	
1	Quantum Field theory: From Operators to Path Integrals, 2nd edition	Kerson Huang (Wiley)
2	Quantum Field Theory	Mark Srednicki

Subject: Simulations in Material Science **Course Code: PSPH-4**	Year & Semester: Pre Ph.D.				Credits 3, L 3, T 0, P 0
New Education/ Evaluation Policy	Mid-Term	Class Assessment	Quiz	Attendance	End-Term
	26 Marks	8 Marks	8 Marks	8 Marks	50 Marks

Credits	L	T	P
3	3	0	0

Sr. No	Course outcomes: Students will
CO1	Students will be Introduced to Basic Programming Skills
CO2	Students will learn some of the Soft-wares used in Material Sciences
CO3	Different Simulation Techniques will be used to Calculate Electrical, Optical & Magnetic Properties

Course contents		Lectures required
Unit	Particulars	
1	Introduction to Computational Physics, Ising model, Heisenberg model of Ferromagnetism Classical Spin Hamiltonian, First principle simulations, Molecular Dynamics, Molecular simulations, Monte – Carlo simulations, LLG equation, Finite Element method.	10
2	Atomistic Modelling of Materials, Integration methods, Atomistic LLG equation, Atomistic Simulation Environment, Micro-Magnetic: Introduction, Dynamics and Micro-Magnetic Modelling, Domain and Domain Walls.	10
3	Density Functional Theory—From Wave Functions to Electron Density, Schrodinger Equation, Multi-Electron System, Born-Oppenheimer Approximation, Hartree Approach, Problem of Hartree Theory, Hartree Vs Hartree fock Equation, Kohn-Sham Theorems, Self-Consistency of Kohn-Sham Equations, Approximation of exchange-Correlation Functional.	10

Recommended Books		
Sr. No	Text Books	Author
1	Introductory Methods of Numerical Analysis 5th edition	S.S Sastry
2	Computational Physics	J.M Thijssen

Subject: Group Theory for Physicists **Course Code: PSPHD-5**	Year & Semester: Pre Ph.D.				Credits: 3, L: 3, T: 0, P: 0
New Education/ Evaluation Policy	Mid-Term	Class Assessment	Quiz	Attendance	End-Term
	26 Marks	8 Marks	8 Marks	8 Marks	50 Marks

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

Course contents		Lectures required
Unit	Particulars	
1	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
2	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
3	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
1	Group Theory for Physicists	A.W. Joshi (New Age International Publishers)
	Reference Books	
1	Unitary Symmetry and Elementary Particles	D.B. Lichtenberg (Acedemic Press)
2	Mathematical Physics	E. Butkov (Pearson)

Subject: Physics at Nanoscale **Course Code: PSPHD-6**	Year & Semester: Pre Ph.D.				Credits	L	T	P
					3	3	0	0
New Education/ Evaluation Policy	Mid-Term	C.A	Quiz	Attendance	End-Term			
	26 Marks	8 Marks	8 Marks	8 Marks	50 Marks			

Sr.No.	Course outcomes:
CO1	Concepts of Nanotechnology and Fabrication of nano materials
CO2	Concept of properties of Nano materials and applications
CO3	Different characterization techniques and their working principles

Course contents		Lectures required
Unit	Particulars	
01	Lecture 1: Why Nano? Size and Maters? Lecture 2: The scientific revolutions – Nanoscience, Nature and Scope, Lecture 3: Surface to volume ratio of nanomaterials. Lecture 4: Quantum effects- classification of nanocrystals Lecture 5: Dimensionality and size dependent phenomena; Lecture 6: Quantum dots, Nanowires and Nanotubes and their properties Lecture 7: Synthesis Techniques: Hydrothermal method, Microwave method, Electrochemical method, sol gel method etc. Lecture 8: Carbon based nanomaterials and their general properties Lecture 9: Graphene and its properties, Potential applications of Graphene Lecture 10: Nanocomposites and Core Shell nanoparticles	10
02	Properties and applications of nanomaterials Lecture 1: Electrical and Transport properties Lecture 2: Applications of nanoparticles in environment and water purification Lecture 3: Applications of nanoparticles in solving energy crisis Lecture 4: Mechanical Properties and tribology Lecture 5: Optical properties, band gap tuning and band gap determination. Lecture 6: Nanostructures under the influence of electrical or magnetic fields Lecture 7: Magnetic properties of nanomaterials, concept of superparamagnetism Lecture 8: Application of nanomaterials in photocatalysis Lecture 9: Biomedical Applications of nanomaterials Lecture 10: Applications of nanomaterials in biology	10
03	Characterization Techniques: Lecture 1: UV-Visible Spectroscopy Lecture 2: Scanning Electron Microscopy (SEM) Lecture 3: Transmission Electron Microscopy (TEM) Lecture 4: X ray Diffraction (XRD) Lecture 5: Vibrating Sample Magnetometer (VSM) Lecture 6: Atomic Force Microscope (AFM), Lecture 7: Fourier Transform Infrared Spectroscopy (FTIR) Lecture 8: Electron spin resonance (ESR) and Nuclear Magnetic Resonance (NMR) Lecture 9: Raman Spectroscopy Lecture 10: Electrochemical characterization techniques	10

Recommended Books		
Sr. N	Text Books	Author
01	Nanoparticle and nanostructure film preparation, characterisation and application	M S R Rao and S Singh, Wiley India
02	Nanoscience and Technology	MA Shah & Tokeer Ahmad (I K International, New Delhi)

Subject: Characterization Techniques **Course Code: PSPHD-7**	Year & Semester: Pre Ph.D.				Credits	L	T	P
					3	3	0	0
New Education/ Evaluation Policy	Mid-Term	Class Assessment	Quiz	Attendance	End-Term			
	26 Marks	8 Marks	8 Marks	8 Marks	50 Marks			

Sr. No.	Course outcomes:
CO1	Fabrication of nano Materials
CO2	Concept of properties of Nano materials
CO3	Different characterization techniques.

Course contents			Lectures required
Unit	Particulars		
1	Light microscopy: bright field, dark field, phase contrast illumination, Ellipsometry: thin-film thickness, optical constants, surface roughness, Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy (STM).		10
2	Spectrophotometry: UV-Visible, Luminescence spectroscopy, Fourier transform infrared (FTIR) spectroscopy, Raman spectroscopy, Surface Plasmon resonance (SPR) spectroscopy, Dynamic light scattering (DLS), inductively couple plasma mass spectroscopy (ICPMS).		10
3	X-ray diffraction (XRD), Transmission electron diffraction (TED) and selected area diffraction. Differential Scanning Calorimeter (DSC), Thermo-Gravimetric and Differential Thermal Analyzer (TG-DTA), Thermal mechanical analysis (TMA), Dynamic mechanical analysis (DMA), Energy Dispersive X-ray analysis (EDAX), X-ray Fluorescence Spectroscopy (XRF), Rutherford Backscattering Spectroscopy (RBS).		10
Recommended Books			
Sr. No.	Text Books	Author	
1	Materials Characterization Techniques	Sam Zhang, Lin Li, Ashok Kumar (CRC Press)	
	Reference Books		
1	Materials Characterization: Introduction to Microscopic and Spectroscopic Methods	Yang Leng (Wiley)	

Seminar of 1 credit shall be as per the guidance of the concerned supervisor with whom he/she is enrolled