DEPARTMENT OF PHYSICS

Hemvati Nandan Bahuguna Garhwal University
(A Central University)
Srinagar Garhwal, Uttarakhand-246174

Syllabus for Pre-Ph D Course: Physics

Duration of the Course- 06 Months

Total Credits: Core: (04+03) =07 + Elective: (04+04) =08 = 15

A. Core Course

S.NO.	Paper Title	Paper Code	Credits
1.	Research Methodology	C-001	04
2.	Research & Publication Ethics and Computational Methods	C-002	03

B. Elective/ Optional Course(Any two of E-001 to E-007)

S. No	Paper Title	Paper Code	Credits
1.	Mathematical Physics	E-001	04
2.	Material Science	E-002	04
3.	Condensed Matter Physics	E-003	04
4.	Laser Physics	E-004	04
5.	Astro Physics	E-005	04
6.	Particle Physics and string theory	E-006	04
7.	Quantum Field Theory	E-007	04

C001- RESEARCH METHODOLOGY (4 Credits)

Part – A (2 Credits)

1. Meaning of research; objectives of research; basic steps of research; criteria of good research; types of research. 2. Meaning of research problem; selection of research problem.3. Review of related literature- Meaning, necessity and sources.4. Hypothesis- Meaning, function and types of hypothesis; Null/Alternative hypothesis. 5. Variables- Meaning and types.6. Research design: Types of research design- exploratory, descriptive, diagnostic and experimental. 7. Statistics and its significance in research 8. Research reports: Writing preliminaries, main body of research, references and bibliography; Meaning and importance of workshop, seminar, conference, symposium etc. in research.

Part – B (2 Credits)

X-ray Diffraction Method (XRD), X-ray Fluorescence Analysis (XRF), UV-visible, IR spectroscopy and Raman Spectroscopy, High Resolution NMR , Ionization Chamber, Scintillation Counter, Spark Counter, Solid State Detectors, Gamma Ray Spectrometer

Suggested Readings:

1. Ahuja, Ram, 2001. Research Methods, Delhi, Rawat publications.
2. Bailey, Kenneth D., 1982. Methods of social research, New York: the Free Press Second edition.
3. Downie N.M. and Heath R.W., 1959. Basic Statistical Methods. New York: Harper and Row Publishers.
4. Frank, Harry and Steven C. Althoen, 1994. Statistics. Concepts and Applications. Cambridge University, 580p.
5. Garg. B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
6. Kothari, C.R., 2008. Research Methodology: Methods and Techniques. Second Edition. New Age International Publishers, New Delhi.
7. Paneerselvam, 2009. Research Methodology, Prentice Hall of India.
8. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes.
17. Sundar Sarukkai, 2008. Indian Philosophy and Philosophy of Science, Motilal Banarsidass Publishers Pvt.Ltd. New Delhi.
9. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270 p.
10. Zikmund, Babin, Carr and Griffin, Research Methodology, Cengage Learning.
11. Introduction to Microscopic and Spectroscopic Methods - Yang Leng, John Wiley & Sons, Singapore.
12. Handbook of Materials Characterization, S.K.Sharma, D.S. Verma, Lati U. Khan, S. Kumar, S.B. Khan, published by Springer Nature, Switzerland.
13. Detection and measuremnt of Nuclear Radiation – G.D. O'Kelley – National Academy of Science, Washington D.C., USA.
14. Nuclear Measurement Techniques – K. Sri Ram, Affiliated East-West Press, Pvt Ltd., New Delhi

C002 - RESEARCH& PUBLICATION ETHICS AND COMPUTATIONAL METHODS (3 Credits)

UNIT I

THEORY: PHILOSPHY AND ETHICS (3hrs.)

Introduction to philosophy: definition, nature and scope, concept, branches, Ethics: definition, moral philosophy, nature of moral judgements and reactions

SCIENTIFIC CONDUCT (5hrs.)

Ethics with respect to science and research, Intellectual honesty and research integrity, Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP), Redundant Publications: duplicate and overlapping publications, salami slicing, Selective reporting and misrepresentation of data

PUBLICATION ETHICS (7hrs.)

Publication ethics: definition, introduction and importance, Best practice/standards setting initiatives and guidelines: COPE, WAME, etc., Conflicts, Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types, Violation of publication ethics, authorship and contributionship, Identification of publication misconduct, complaints and appeals, Predatory publication and journals

UNIT- II

PRACTICE: OPEN ACCESS PUBLISHING (4hrs)

Open access publications and initiatives:

SHERPA/RoMEO online resource to check publisher copyright & self-archiving, Policies, Software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggested, etc.

PUBLICATION MISCONDUCT

A. Group Discussions (2hrs.)

Subject specific ethical issues, FFP, authorship, Conflicts of interest, Complaints and appeals: examples and fraud from India and abroad

B. Software tools (2hrs.)

Use of plagiarism software like Turnitin, Urkund and other open source software tools

DATABASES AND RESEARCH METRICS (7hrs.)

A. Databases (4hrs.)

1. Indexing databases
2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics (3hrs.)

1. Impact Factor of journal as per Journal Citation Report, SNIP SJR, IPP, Cite Score
2. Metrics: h-index, g index, altmetrics.

UNIT III:

COMPUTATIONAL METHODS

Application of Scientific and Mathematical Software: FORTRAN 90/95, C/ C++, Maple, Mathematica and MATLAB.

Suggested Readings:

1. Numerical Methods- E Balagurumurty (Tata Mac-Grow Hill)
2. Computer Programming in Fotran 90/95- V Rajaraman(PHI)
3. C++ Programming(B Stroustrup) Pearson
4. C- Programming – R Rajaraman (PHI)
5. Solving Problems in Scientific Computing Using Maple and MATLAB , 3rd Ed. W. Gander J. Hrebicek,1997.

Elective/ Optional

E001- MATHEMATICAL PHYSICS (4 Credits)

Unit I - Differential Equations: Solutions of Legendre and Associated Legendre equations. Hermite equation, Laguerre equation, Bessel's equations.

Unit II- Fourier and Laplace Transforms, Laplace equation and its solution, Poisson, Diffusion and Wave equations, Vibrating membrane.

Unit III -Matrices and Tensors: Solution of Linear equations, Eigen values and Eigen Vectors, Matrix Inverse, Coordinate transformation, Covariant and contravarient Tensors, addition, multiplication and contraction of tensors, Associated tensors.

Unit IV- Numerical Methods: Interpolation, Numerical Differentiation, Integration, Solution of Linear Equations.

Suggested Readings:

1. G Arfken: Mathematical Methods for Physicist (Academic Press)
2. Pipes and Harvil: Mathematical Methods for Engineers and Physicist
3. C Harper: Introduction to Mathematical Physics (Prentice Hall of India)
4. Mathematical Physics- B D Gupta.
5. Mathematical Physics, Dass and Verma
6. Numerical Methods- E Balagurumurty (Tata Mac-Grow Hill)

E002- MATERIAL SCIENCE (4 Credits)

Unit I - Crystal growth techniques

Introduction to different crystal growth techniques. Nucleation and growth: Homogeneous and heterogeneous nucleation, growth mechanism, Continuous and discontinuous reactions, precipitation, solidification, casting, zone refining.

Unit II - Nano Materials

Introduction and importance of nanostructured materials, Quantum confinement, surface effect, synthesis techniques and properties of 0D, 1D , 2D and super lattice structures, Applications of nanostructured materials, Size dependent optical, electronic and magnetic properties of nanostructured materials, Carbon nano-tubes , quantum wires. Functional materials and nanocomposites

Unit III - Biomaterials

Biomaterials, Common use of biomaterials as metal, ceramic and polymer and their chemical structures, properties and morphology and basic concept of biocompatibility.

Unit IV – Electron Microscopy

Transmission electron microscopy, scanning electron microscopy, scanning probe microscopy (STM and AFM), analytical electron microscopy

Suggested Readings:

1. Pradeep T "Nano: The Essentials", Mc Graw Hill Publishing Co. Ltd., 2007
2. Mick Wilson et al, "Nanotechnology", Overseas Press (India) Pvt. Ltd., 2005
3. Hench L. Larry, and Jones J., (Editors), Biomaterials, Artificial organs and Tissue Engineering, Woodhead Publishing Limited, 2005.
4. William D. Callister, Materials Science & Engineering: An Introduction, John Wiley & Sons (2007)
5. William F. Smith, Foundations of Materials Science & Engineering, McGraw Hill International Edition (1993)
6. Edward L Wolf ,Nanophysics and Nanotechnology, Wiley VCH, 2004

E003 - CONDENSED MATTER PHYSICS (4 Credits)

Unit I - Thermal, electrical properties and Band Theory of Solids: Phonon density of states, Lattice Specific heat, Lattice Thermal conductivity, Heat capacity of electron gas, Free electron Theory, Electrical conductivity, Electron density of states, Electronic specific heat. Band theory: Kroning - Penny Model, Brillouin Zones, distinction between metals, semiconductors and insulators.

Unit II - Imperfections in Solids: Point defects- interstitial, substitutional impurities, Vacancies, Frenkel and Schottky defects, extrinsic vacancies, Diffusion, Colour centres, dislocations, grain boundaries, staking faults, crystal growth, Structure of metals and solid solutions.

Unit III - Superconductivity- Meissner effect, Isotope effect, London Equation, Type-I , Type-II Super Conductors, Flux Quantisation, Persistent current, London Theory, GL Theory, B C S Theory, Josephson's effect (AC & DC0, High Tc Superconductors, Applications of Superconductors.

Unit IV - Dielectrics and Ferroelectrics- Different Kinds of Polarizations in dielectrics, Clausius -Mossotti relation, Ferroelectricity, Classification of ferroelectrics, Order Disorder and Displacive, Landau's Theory, Cochran's Theory, Antiferroelectricity, Domains, Piezoelectricity, Pyroelectricity, Applications of Ferroelectrics.

Reference Books:

1. C Kittel, Introduction to Solid State, John Wiley & Sons.
2. R A Levy, Priciples of Solid State Physics, Academic Press, Newyork
3. R L Singhal, Solid State Physics, Kedarnath Ramnath, Meerut
4. J H Crawford, Jr. and L. M. Slifkin (eds.), Point Defects in Solids, Vol. 1. General and Ionic Crystals, Plenum, New York (1972).
5. H V KEER,Principle of the solid state, New Age International.
6. S O Pillai, Solid State Physics, New Age international.
7. N W Ashcroft et al., solid State Physics, CENGAGE LEARNING Asia.
8. Patterson &Bailey, Solid State Physics : Introduction to Theory, Springer

E004- LASER PHYSICS (4 Credits)

Unit I - Rate equations for three and four level laser systems; population inversion; theory of optical resonators; laser modes; fabrication technology of lasers; diode lasers, colour centre and spin flip lasers; laser spikes, moel locking, Q-switching, CW and pulsed lasers.

Unit II - Laser Spectroscopy: Laser fluorescence spectroscopy using CW and pulsed lasers; single photon counting; Laser Raman Spectroscopy, multi photon processes, photo acoustic and photon electron spectroscopy, stimulated Raman spectroscopy, coherent antistoke Raman Spectroscopy.

Unit III - Optical Sources and Detectors: Laser devices, Radiation pattern and modulation, LED structures, light source materials, liquid crystal diodes, photoelectric, photovoltaic and photoconductive methods of of detection of light, **Photo diodes;**structure, materials and working. PIN photo diodes, avalanche photo diodes, micro channel plates, photo detectors noise responsively and efficiency, photomultipliers

Unit IV - Fibre Optics: Basic characteristics of optical fibres, fibre structure and fundamentals of waveguides, step and graded index fibres, signal degradation in optical fibres, absorption scattering, radiation and core cladding losses, Design considerations of a fibre optical communication system, analogue and digital modulation, optical fibre amplifiers.

Suggested Readings:

1. Ghatak and Thygrajan: Lasers
2. O.Svelto: Principles of Lasers
3. Silvfast: Lasers
4. B B Loud; Lasers
5. Ghatak and Thygrajan: optical electronics
6. Hawks: Optoelectronics
7. Keiser: Optical Fibre Communications
8. Ghatak and Thygrajan: Intoduction to fibre optics
9. I P Csorba: Image tubesEd.L M Bibermmam and S.Hudelman: Photoelectronics

E005 – ASTROPHYSICS (4 Credits)

Unit – I: Overview of major contents of universe, Laws of planetary motion, Motions and distances of stars, Statistical and moving cluster parallax, Black body radiation, Specific intensity, flux density, luminosity, Basics of radiative transfer (Emission/absorption coefficients, source functions), Magnitudes, distance modulus, colour index, Extinction, Colour temperature, effective temperature, Brightness temperature, bolometric magnitude/luminosity, Excitation temperature, kinetic temperature.

Unit – II: Coordinate systems, precession, time, heliocentric corrections, methods of observation, resolution, Sensitivity, noise. Telescopes at different wavelengths, detectors at different wavelengths, imaging, atmospheric effects at different wavelengths

Unit – III: H R Diagram, discussion on the variety of stellar phenomena, the various reaction chains, stellar equations, utility of stellar spectrum, basic knowledge of stellar atmospheres.

Unit – IV: Binaries, variable stars, clusters, open and globular clusters, velocity dispersion, final stages of stellar evolution, supernova and neutron stars- a basic knowledge of NS structure rate, Shape, size and contents of our galaxy, normal and active galaxies, Newtonian and Einstein cosmology, microwave background, early Universe.

Reference Books:

1. Shu F, The Physical Universe, University of California,1982
2. Harwit M, Astrophysical concepts, 3rd ed.,Springer Verlag, 2006
3. Padmnabhan T, Theoretical Astrophysics, Vol.1-3,Cambridge University Press, 2005
4. Arnett, Supernovae & Nucleosynthesis
5. Introduction to Stellar Astrophysics, vol.3; Stellar structure and evolution-Erika Bohm-Vitense.
6. Black Holes, White Dwarfs & Neutron Stars-Shapiro & Teukolsky
7. Stellar structure and evolution-R.Kippenhahn & A Weigert
8. Principles of Stellar evolution- D Clayton
9. Neutrino Astrophysics-J Bahcal
10. Astronomy: A Physical Prospective-Kutner
11. Astronomy Principles and Practice,4th ed.Institute of Physics'2003-Roy A E & Clarke D.
12. Astrophysical Techniques, 4th ed., Institute of Physics,2003,Kitchin C R

E006 – PARTICLE PHYSICA AND STRING THRORY (4 Credits)

Unit I - Motion of a non-relativistic string, normal modes. Review of Special theory of Relativity, light cone coordinates, Lorentz invariance in diverse dimensions, small and compact dimensions, square-well and quantum mechanics of extra dimensions, motion of a relativistic particle, world-line.

Unit II - Review of electromagnetism, electric field in diverse dimensions, point particle with electric charge.Newton's law of gravitation in diverse dimensions; Planck units of mass, length and time, Newton's constant, gravity and geometry.

Unit III - Relativistic string, world-sheet, invariant on the world sheet, area of embedded surfaces, Nambu-Goto action, equations of motion, boundary conditions and branes, static gauge, tension and energy of strings.

Unit IV - Classical motion of a string, dynamics on the world-sheet, conserved quantities.

Point particle in light-cone gauge, quantization. String in light-cone gauge, string as oscillators, normal modes and particle spectrum (open and closed string), quantization.

String thermodynamics: counting of states, partition function. Overview of results.

Suggested Readings:

1. B.Zwiebach, A first course in string theory(Cambridge University Press)
2. H.Goldstein, Classical mechanics (Addison-Wesley)
3. J.Hartie, Gravity: An introduction to Eiensteins general relativity (Pearson education)
4. J.Sakurai, Modern Quantum Mechanics (Pearson Education)
5. L.Schiff, Quantum mechanics (McGraw-Hill)

E007 – QUANTUM FIELD THEORY (4 Credits)

Unit I - Introduction to the quantization of wave fields: Classical and quantum fields equations:coordinates of the field, Time derivatives, Classical Lanrangian Equations, Funstional derivatives, Classical Hamiltonian equations, Quantum equations for the field, Fields with more than one component, Complex Field.
Quantization of the non relativistic Schrödinger Equations: Classical Lagrangian and Hamiltonian equations, Quantum equations, The N-representations, Creation and destruction operators, Number operator, Anticommutation Relations, Equation of motion, Physical implications of Anticommutation, Representation of anticommuting operators
Unit II - Quantization of fields: Quantization of neutral and complex scalar fields, Quantization of Dirac field covariant anticommutation relations, Quantization of electromagnetic field. Interaction Lagrangian for the fields, QED Lagrangian.
Unit III - Scattering Matrix and Feynman Rules: The S-Matrix reduction of S-Matrix chronological product, Wicks theorem Furry's theorem, Covariant perturbation theory, interaction Lagrangian for QED, Feynman Diagrams and Feynman rules for QED in configuration and momentum space, Electron-Positron scattering, Coulomb scattering of Electrons, electron-positron annihilation, Compton scattering.
Unit IV - Renormalization of QED: Self energy correction, vacuum polarization and vertex correction, classification of Divergences, Renormalization of mass and charge, wave function renormalization.

Suggested Readings:

1. Quantum Mechanics, L.I.Schiff
2. Theory of photons and electrons, J.M.Jauch and E.Rohrlich
3. Relativistic Quantum fields, J.D.Bjorkenand S.D.Drell.
4. Quantum electrodynamics,A.I.Akhiezer and berestetskl
5. Quantum field theory, Lewis H.Ryder
6. Quantum field theory IN A NUTSHELL, A.Zee
7. The theory of quantized fields, N.N.Bogoliubov and D.V.Shirkov
8. Relativistic Quantum Field Theory, S.S.Schweber