Centre for Physical Sciences
Scheme of Programme: Ph.D. in Physics (2017-18)

S. No.	Paper Code	Course Title	L	T	P	Cr	
1	PHY.701	Research Methodology	4	0	0	4	100
2	PHY.702	Statistics and Computer Applications	3	0	2*	4	100
3	PHY.703	Review Writing and Seminar Presentation	4	0	0	4	100
Choose any one of the following#							
4	PHY.704	Condensed Matter Physics	4	0	0	4	100
5	PHY.705	Thin Film and Vacuum Technology	4	0	0	4	100
6	PHY.706	Nanostructured Materials	4	0	0	4	100
7	PHY.707	Density Functional Theory and Applications	4	0	0	4	100
8	PHY.708	1D Nanomaterials Synthesis and Characterization	4	0	0	4	100
9	PHY.709	Energetic Materials and Storage Devices	4	0	0	4	100
10	PHY.710	Accelerator and Plasma					
			15	0	2*	16	400

* 2 practical hours are equivalent to 1 credit hour.
# Elective course will be decided by the guide/supervisor of the student

Course Title: Research Methodology
Paper Code: PHY.701
Total Lectures: 60

L	T	P	Credits	Marks
4	0	0	4	100

Course Objective: The course Research Methodology has been framed to introduce basic concepts of Research Methods. The course covers preparation of research plan, reading and understanding of scientific papers, scientific writing, research proposal writing, ethics, plagiarism, laboratory safety issues etc. The course also covers important experimental techniques in order to teach the same that will help to doctoral students in carrying out experiments.

Unit I **(18)**

Introduction: Meaning and importance of research, Different types and styles of research, role of serendipity, Critical thinking, Creativity and innovation, Hypothesis formulation and development of research plan, Art of reading and understanding scientific papers, Literature survey, Interpretation of results and discussion. **Library:** Classification systems, e-Library, Reference management, Web-based literature search engines, Intellectual property rights (IPRs).

Unit II **(18)**

Scientific and Technical Writing: Role and importance of communication, Effective oral and written communication, Scientific writing, Research paper writing, Technical report writing, Making R&D proposals, Dissertation/Thesis writing, Letter writing and official correspondence, Oral and poster presentation in meetings, seminars, group discussions, Use of modern aids; Making technical presentations. **Research and academic integrity:** Plagiarism, copyright issues, ethics in research, and case studies. **Laboratory safety issues:** lab, workshop, electrical, health & fire safety, safe disposal of hazardous materials.

Unit III **(14)**

Microscopic and Imaging Techniques: Basics of electron and light microscopy, Polarizing optical microscopy (POM), Fluorescent microscopy, Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Bright and dark field imaging, Scanning-probe microscopy (SPM), Atomic force microscopy (AFM), Raman spectroscopy, Ion Beam Techniques in Materials Science.

Unit IV **(10)**

Spectroscopic Techniques: UV-Visible Spectroscopy, Infra red spectroscopy, photoluminescence spectroscopy, Impedance/dielectric spectroscopy.

Recommended Books:

1. S. Gupta, *Research Methodology and Statistical techniques* (Deep and Deep Publications (P) Ltd. New Delhi, India) 2005.
2. C. R. Kothari, *Research Methodology* (New Age International, New Delhi, India) 2008.
3. G. Haugstad, *Atomic Force Microscopy: Understanding Basic Modes and Advanced Applications* (John Wiley & Sons, Sussex, U.K) 2012.
4. B.S Murty, P.Shankar, B. Raj, B. B. Rath, and J. Murday, *Textbook of Nanoscience and Nanotechnology* (Springer, New York, USA) 2013.
5. **Web resources:** www.sciencedirect.com for journal references, www.aip.org and www.aps.org for reference styles.
6. **Web resources:** www.nature.com, www.sciencemag.org, www.springer.com, www.pnas.org, www.tandf.co.uk, www.opticsinfobase.org for research updates.

Course Title: Statistics and Computer Applications
Paper Code: PHY.702
Total Lectures: 45

L	T	P	Credits	Marks
3	0	2	4	100

Total Lab Hours: 30

Course Objective: The course **Statistics and Computer Applications** has been designed to introduce basic concepts of data analysis. The course covers errors and uncertainty, various types of distributions, least square fitting etc. The course also contains the basics of MATLAB language to solve the numerical problems.

Unit I **(07)**

Introduction: Measuring errors, Uncertainties, Parent and sample distributions, Mean and standard deviation of distribution.

Unit II **(09)**

Probability Distributions: Binomial distribution, Poission distribution, Gaussian distribution and Lorentzian distribution. **Error Analysis:** Different types of errors: Instrumental, Statistical errors, Propagation of errors, Error formulae, Application of error equation.

Unit III **(12)**

Least Square Fitting: Least-square fitting to a straight line by minimizing χ^2, Error estimation, Least-square fit to a polynomial, Matrix solution, Least-square fit to an arbitrary function, Nonlinear fitting, Grid search method, Gradient search method, Expansion method and Marquardt method.

Testing the Fit: χ^2 test for goodness of fit, Linear-correlation coefficient, Multivariable correlations, Confidence intervals, Monte Carlo tests.

Unit IV **(17)**

Introduction to MATLAB: Standard Matlab windows, Operations with variables: Arrays: Columns and rows: creation and indexing, Size and length, Multiplication, Division, Power, Writing script files: Logical variables and operators, Loop operators; Writing functions: Input/output arguments, Simple graphics: 2D plots, Figures and subplots; Data types: Matrix, string, cell and structure, File input-output, Polynomial fit: 1D and 2D fits; Arbitrary function fit: Error function, Goodness of fit: criteria, Error in parameters; Graphics objects, Differentiation and integration through MATLAB, Solution of system of linear equations using MATLAB.

Recommended Books:

1. P. G. Guest, *Numerical Methods of Curve Fitting* (Cambridge University Press, Cambridge, U. K.) 2012.
2. Z. A. Kotulski and W. Szczepinski, *Error Analysis with Applications in Engineering* (Springer, New York, USA) 2010.
3. J. D. Vore, *Probability and Statistics for Engineering and Sciences* (Cengage Learning India Private Limited, New Delhi, India) 2012.
4. P. R. Bevington and D. K. Robinson, *Data Reduction and Error analysis for the Physical Sciences* (Tata McGraw Hill, Noida, India) 2003.
5. R. Pratap, *Getting Started with MATLAB* (Oxford University Press, Oxford, U. K.) 2010.

6. B. R. Hunt, R. L. Lipsman, J. M. Rosenberg, *A Guide to MATLAB: For Beginners and Experienced Users* (Cambridge University Press, Cambridge, U. K.).
7. S. Otto and J. P. Denier, *An Introduction to Programming and Numerical Methods in MATLAB* (Springer, New York, USA) 2005.

Course Title: Review Writing and Seminar Presentation
Paper Code: PHY.703
Total Lectures:120

L	T	P	Credits	Marks
0	0	8	4	100

Objective: The objective of this course would be to ensure that the student learns the aspects of the Review writing and seminar presentation. Herein the student shall have to write a 5000 words review of existing scientific literature with simultaneous identification of knowledge gaps that can be addressed through future work.

The evaluation criteria for "Review Writing and Presentaion" shall be as follows:
Maximum Marks: 200

S.No.	Criteria	Marks
1.	Review of literature	25
2.	Identification of gaps in knowledge	15
3.	References	10
4.	Content of presentation	15
5.	Presentation Skills	20
6.	Handling of queries	15
Total		**100**

Course Title: Condensed Matter Physics
Paper Code: PHY.704
Total Lectures: 60

L	T	P	Credits	Marks
4	1	0	4	100

Course Objective: The purpose of this course is to introduce students to the fundamental and advanced concepts of solid materials. The topics include Band gap in semiconductor, Plasmons, Dielectric, optical, ferroelectric properties, Alloys, Magnetism, Magnetic materials and Magnetic resonances.

Unit I **(15)**

Semiconductor Crystals: Band gap, Equation of motion, Effective mass, Intrinsic carrier concentration, Impurity conductivity, Thermoelectric effects.
Fermi Surfaces and Metals: Construction of Fermi surfaces, Electron orbits, Hole orbits and open orbits, Calculation of energy bands, Experimental methods in Fermi surface studies.

Unit II **(15)**

Plasmons, Polaritons, and Polarons: Dielectric function of the electron gas, Plasmons, Electrostatic screening, Plasma oscillations, Transverse optical modes in plasma, application to optical phonon modes in ionic crystals, Interaction of EM waves with optical modes: Polaritons, LST relation, Electron-electron interaction, Electron-phonon interactions: Polarons.

Optical Properties, Color Centers and Excitons: Optical reflectance, Optical properties of metals, Luminescence, Types of luminescent systems, Electroluminescence, Color centers, Production and properties, Types of color centers, Excitons (Frenkel, Mott-Wannier), Experimental studies (alkali halide and molecular crystals), Raman effect in crystals, Energy loss of fast particles in a solid.

Unit III **(15)**

Dielectrics and Ferroelectrics: Polarization, Macroscopic and local electric field, Dielectric constant and polarizability, Pyroelectric and ferroelectric crystals and classification, Polarization catastrophe, Soft modes, Phase transitions, Landau theory of phase transition, Antiferroelectricity, Piezoelectric crystals, Applications.

Noncrystalline solids and Alloys: Diffraction pattern, Glasses, Amorphous ferromagnets, Amorphous semiconductors, Low energy excitations in Amorphous solids, Fiber optics, Substitutional solid solutions Hume-Rother rules, Order-disorder transformation. Phase diagrams, Transition metal alloys, Kondo effect.

Unit IV **(15)**

Magnetism, and Magnetic Resonance: Types and properties of magnetism, Spin waves, Magnons, Magnon dispersion relations, Bloch $T^{3/2}$ Law, Electron spin resonance (ESR), Nuclear magnetic resonance (NMR), Spin relaxation (spin-lattice, spin-spin), Applications of ESR and NMR.

Magnetic Materials: Soft and hard magnetic materials, Hysteresis loop, Magnetic susceptibility, Coercive force, Ferrites, Magnetic anisotropy and Induced magnetic anisotropy, Magneto-striction and effects of stress, Magnetic materials for recording and computers, Magnetic measurements Techniques.

Recommended books:

1. J. Ziman, *Principles of the Theory of Solids* (Cambridge University Press, Cambridge, U.K.) 2011.
2. C. Kittel, *Introduction to Solid State Physics* (Wiley India (P) Ltd., New Delhi, India) 2007.
3. R.J. Singh, *Solid State Physics* (Pearson, New Delhi, India) 2011.
4. A.J. Dekker, *Solid State Physics* (Macmillan, London, U.K.) 2012.

Course Title: Thin Film and Vacuum Technology
Paper Code: PHY.705

L	T	P	Credits	Marks
4	1	0	4	100

Total Lectures: 60

Course Objective: To introduce thin film deposition techniques and study of its optical, electrical, magnetic and mechanical properties and applications of thin films. It also aims to introduce basics of vacuum techniques, vacuum measurement systems and leak detection techniques.

Unit I **(15)**

Thin Films: Classification of thin films, Preparation methods: Electrolytic deposition, Thermal evaporation, Spray pyrolysis, Spray pyrolysis, Sputtering Pulse laser deposition, LB, Spin coating, Dip coating solution cast, Tape casting, Sol gel Sputtering, Chemical vapour deposition, Molecular beam epitaxy, Cluster beam evaporation, Ion beam deposition, Chemical bath deposition with capping techniques, Thickness measurement and monitoring, Electrical, Mechanical, Optical interference.

Unit II **(15)**

Properties and Applications of Films: Elastic and plastic behavior, Optical properties, Reflectance and transmittance spectra, Anisotropic and gyrotropic films, Electric properties of films: Conductivity in metal, semiconductor and insulating films, Dielectric properties, Micro and optoelectronic devices, data storage, Optical applications, Electric contacts, resistors, Capacitors and inductors, Active electronic elements, Integrated circuits.

Unit III **(15)**

Vacuum Techniques Basics: Basic elements of vacuum science, Viscous and molecular flow, Conductance, Performance measure: Pumping speed, Throughput, Uses of vacuum pumps, Operating pressure range.

Positive Displacement Pumps: Rotary pump, Scroll pump, Momentum transfer or molecular pumps, Diffusion and turbo molecular pump.

Entrapment Pumps: Ion pumps, Sputter pumps, Cryo pumps, Sorption pumps, Design of ultra high vacuum systems.

Unit IV **(15)**

Vacuum Measurement Systems: Vacuum measurement gauges, Hydrostatic gauges, Mechanical or elastic gauges, Thermal conductivity gauges, Ion gauges, Control and interlock systems.

Leak detection techniques: Types of leaks, Bubble test, Pressure decay test, Tracer gas leak testing using helium gas.

Recommended Books:

1. B.S Murty, P. Shankar, B. Raj, B.B. Rath, and J. Murday, *Textbook of Nanoscience and Nanotechnology* (Springer, New York, USA) 2013.
2. A. Kapoor, *An Introduction to Nanophysics and Nanotechnology* (Alpha Science International, New Delhi, India) 2011.
3. K. Seshan, *Handbook of Thin Film Deposition Processes* (Elsevier, London, U. K.) 2012.

4. D. Gall, S. P. Baker and M. Ohring, *Materials Science of Thin Films: Deposition and Structure* (Academic Press, Massachusetts, USA) 2013.
5. A. Roth, *Vacuum Technology* (Elsevier Science Publishers, New York, USA) 1990.
6. J.F. O'Hanlon, *A Users Guide to Vacuum Technology*, (John Wiley & Sons, New York, USA) 1989.
7. J.M. Lafferty, *Foundations of Vacuum Science and Technology* (John Wiley & Sons, New York, USA) 1998.

Course Title: Nanostructured Materials
Paper Code: PHY.706
Total Lectures: 60

L	T	P	Credits	Marks
4	1	0	4	100

Unit I **(15)**

Synthesis: Introduction to nanotechnology and nanomaterials, Top down and bottom up approaches, Sol-gel, Spin and dip coating, Pulsed Laser Diposition (PLD), Molecular beam epitaxy, Spray pyrolysis, Sputtering, Electron beam lithography, Ion beam lithography, Ball milling, Laser ablation, Thermal and ultrasonic decomposition, Reduction methods, Self-assembly, Focused ion beams, Nanoimprinting, Nanostructuring and modification by swift heavy ions (SHI).

Unit II **(10)**

Nanomaterials: Carbon fullerenes and CNTs, Metal and metal oxides, Self-assembly of nanostructures, Core-shell nanostructures, Nanocomposites, Quantum wires, Quantum dots.

Unit III **(20)**

Characterization: Characterization of nanomaterials for the structure, High resolution X-Ray diffractogram, High resolution transmission electron Microscopy (HRTEM), Fluorescent microscopy, Scanning electron microscopy (SEM), Scanning tunneling microscopy (STM), Bright and dark field imaging, Scanning-probe microscopy (SPM), Field emission scanning electron microscopy (FESEM), Atomic force microscopy (AFM), Impedance spectroscopy, Dielectric spectroscopy, Fourier transform infrared spectroscopy (FT-IR)**,** Raman Spectroscopy, Thermogravimetric Analysis (TGA), Differential scanning calorimetry (DSC), Dynamic mechanical analysis, Universal tensile testing, Transport number, Electron spin resonance, UV spectrophotometer.

Unit IV **(15)**

Physical Properties of Nanomaterials: Dielectric, Magnetic, Optical, Mechanical and photocatalytic properties.

Applications: Electronic devices based on nanostructures, High electron mobility transistors, Nanomagnetism, Surface/interface magnetism, Nanophotonics, Solar cell, Memory devices, Supercapacitors, Lithium ion batteries, Fuel cells, Organic semiconductors, Ferro-fluids.

Recommended Books:

1. G. Haugstad *Atomic Force Microscopy: Understanding Basic Modes and Advanced Applications* (John Wiley & Sons, New Jersey, USA) 2012.
2. B.S. Murty, P. Shankar, B. Raj, B.B. Rath and J. Murday, *Textbook of Nanoscience and Nanotechnology* (Springer, Sussex, UK) 2013.
3. K.D. Sattler, *Handbook of Nanophysics* (CRC press, Florida, USA) 2010**.**
4. C.G. Wing, J.L.R. Lpez, O.A. Graeve, and M.M. Navia, *Nanostructured Materials and Nanotechnology* (Cambridge University Press,Cambridge, UK) 2013.

Course Title: Density Functional Theory and Applications
Paper Code: PHY.707
Total Lecture: 60

L	T	P	Credits	Marks
4	0	0	4	100

Course Objective: The objectives of this course are to understand the basics of Density Functional Theory (DFT). With the increasing power of computers, DFT-based calculations are emerging as an useful tool to characterize the materials properties. This course will review the various theories/approximations necessary to understand most popular framework of modern DFT.

Unit-I **(16)**

Many-body Approximations: Schrodinger equation and its solution for one electron and two electron systems, Hamiltonian of many particles system, Born-Oppenheimer approximation, Hartree theory, Idea of self consistency, Exchange energy and interpretation, Identical particles and spin, Hartree-Fock theory, Antisymmetric wavefunctions and Slater determinant, Koopmans' theorem, Failures of Hartree-Fock in solid state, Correlation energy, Variational principle, Connection between Quantum Mechanics,Variational Principle and Classical Mechanics.

Unit-II **(16)**

From Wave Functions to Density Functional: Idea of functional, Functional derivatives, Electron density, Thomos Fermi model, Hohenberg-Kohn theorems, Approximations for exchange-correlation: Local density approximation (LDA) and local spin density approximation (LSDA), Gradient expansion and generalized gradient approximation (GGA), Hybrid functionals and meta-GGA approaches. Self-interaction corrections (SIC).

Unit-III **(14)**

Practical Implementation of Density Functional Theory (DFT): Kohn-Sham formulation: Plane waves and pseudopotentials, Janak's theorem, Ionization potential theorem, Self consistent field (SCF) methods, Understanding why LDA works, Consequence of discontinuous change in chemical potential for exchange-correlation, Strengths and weaknesses of DFT.

Unit-IV **(14)**

Electronic Structure with DFT: Free electron theory, Band theory of solids, Tight-binding method, Semiconductors, Band structure, Density of states. Interpretation of Kohn-Sham eigenvalues in relation with ionization potential, Fermi surface and band gap. Electronic structure of Graphene

Recommended Books:

1. Richard M. Martin, Electronic Structure: Basic Theory and Practical Methods, (Cambridge University Press, 2004)
2. Robert G. Parr and Weitao Yang, *Density Functional Theory of Atoms and Molecules*, (Oxford University Press, 1994).
3. David S. Sholl and Janice A. Steckel, *Density Functional Theory: A Practical Introduction* (John Wiley and Sons, 2009).
4. June Gunn Lee, *Computational Materials Science: An Introduction*, (CRC Press 2011)
5. C. Kittel, *Introduction to Solid State Physics* (Wiley India (P) Ltd., New Delhi, India) 2007

Course Tile: 1D Nanomaterials Synthesis and Characterization
Paper Code: PHY.708

L	T	P	Credits	Marks
4	0	0	4	100

Total Lectures: 60

Course Objective: This course aims to introduce the variety of one-dimensional (1D) nanomaterials, manipulate the processes to create 1D nanostructure, analyze those structures with various techniques, and understand their structure-properties relationship for utilization in the variety of applications.

Unit 1: **(14)**

Nanomaterials and Nanostructures: Introduction to nanotechnology and nanomaterials, Going Public: Risk, Trust and Public Understanding, Types of nanomaterials (i.e. Zero (0), One (1), Two (2), and Three (3) dimensional), Science (Physics and Chemistry) of 1D nanomaterials, unique electrical, optical, mechanical, chemical, and magnetic properties at 1D nanoscale, Growth mechanisms 1D nanostructures, Vapor-Liquid-Solid (VLS) growth, Solution-Liquid-Solid (SLS) growth, Vapor-Solid growth, advantages of 1D nanostructures, Challenges and Future of 1D nanostructures, possible applications.

Unit 2: **(16)**

Synthesis of 1D nanomaterials: Processing of 1D nanomaterials, top-down and bottom-up approaches, various physical and chemical techniques of synthesis (e.g. physical vapor deposition, chemical vapor deposition, hot-filament vapor deposition, Pulsed Laser Deposition, confinement growth, glancing angle, sol-gel technique, hydrothermal synthesis etc.) Importance of materials from applications view point (case studies).

Unit 3: (16)

Characterization Techniques: Characterization of 1D nanostructures, Concepts and utilization of Field Emission Scanning electron microscopy (FESEM), Energy Dispersive X-ray spectroscopy (EDS), Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM), Transmission Electron Microscopy (TEM), High-Resolution Transmission Electron Microscopy (HR-TEM), Selected Area Electron Diffraction (SAED), X-ray Diffraction (XRD), X-ray Photoemission Spectroscopy (XPS), Angle-resolved X-ray Photoemission Spectroscopy (ARPS), Valance Band Spectroscopy (VBS), UV-VIS spectroscopy, and Raman spectroscopy for analysis of various 1D nanomaterials (case studies).

Unit 4: (14)

Applications: Dye Sensitized Solar Cells (1D nanomaterials and concepts involved in the fabrication, property measurements) Supercapacitor and Electrochromic smart displays devices (1D nanostructures and various electrolytes utilized, device fabrication, property measurements and other related concepts), Field Emitters (basic concepts of using 1D nanostructures, device fabrication etc) Nanogenerators (working principles, fabrication and utilization), Nanoelectronics (advantages, disadvantages and other related concepts of utilizing 1D nanomaterials, fabrication of various electronic components e.g. diodes, transistors etc) Hydrogen production (Photovoltaic and photoelectrochromic), gas sensors, Resistive switching devices, and LED etc.

Books

1. Nanoparticles: Synthesis, Characterization and Applications by R. S. Chaughule and R. V. Ramanuja, American Scientific Pulishers (2010)
2. Nanomaterials and Nanochemistry by C. Brechignac, P Houdy and M. Lahmani, Springer (2007)
3. A Textbook of Nanoscience and Nanotechnology by T. Pradeep, McGraw Hill Edu. (India) Pvt. Ltd. (2016)
4. Nanostructures and Nanomaterials: Synthesis, Properties and Applications by Guozhong Gao, Imperical College Press, 2004
5. Transmission Electron Microscopy: A Textbook for Materials Science by D. B. Williams, and C. B. Carter, Springer (2009)
6. Elements of X-ray diffraction by B. D. Cullity, PEARSON, 2016

Course Tile: Energetic materials and storage devices

Paper Code: 709

Total Lectures: 60

L	T	P	Credits	Marks
4	0	0	4	100

Course Objective: This course aims to introduce different materials use in development of solar cell starting from importance of material, band engineering in device assembly and its device characterizations.

Unit: 1 (15)

Materials for energy conversion and storage devices: Nanomaterials, Mesoporous materials, Biomaterials, Carbon based materials, Best absorbing materials, electron transport materials, hole transport materials, Perovskites and oxides

Unit: 2 **(15)**

Material synthesis: Physicochemical method, Electrochemical method, Spin coating, Dip coating, Sol-gel, Spray pyrolysis, Doctor blade, Hydrothermal, Chemical bath deposition, Chemical vapor deposition, Physical vapor deposition (DC/RF Magnetron sputtering, Electron beam evaporation, LASER ablation etc).

Unit: 3 **(15)**

Band engineering: Electron in a crystal, Intrinsic semiconductor, Extrinsic semiconductor, Alignment of Fermi levels, Drift of electrons in an electric field, Mobility, Drift current, Diffusion current, Generation/Recombination Phenomena, Origin of bands, Band theory, Models of band engineering, Schottky diode, Ohmic contact

Unit: 4 **(15)**

Energy Conversion Devices: Solid state devices, Solid state mesoscopic solar cells, Silicon based solar cells, Dye sensitized solar cells, Organic solar cells, Dark current measurement, Calculation of efficiency, Supercapacitors, Batteries.

References:

1. Nanotechnology: Principles and Practices, Sulabha K. Kulkarni, Springer.
2. Textbook of Nanoscience and Nanotechnology, B.S. Murty, P. Shankar, Baldev Raj, B B Rath, James Murday , Springer
3. Synthesis, Structure, and Properties of Organic-Inorganic Perovskites and Related Materials, David B. Mitzi, Progress in Inorganic. Chemistry Vol. 48
4. Physics of Semiconductor Devices, J P Colinge And C. A. Colinge, Kluwer Academic Publishers.
5. Supercapacitors: Materials, Systems, and Applications, Francois B´eguin, Wiley-VCH Verlag GmbH & Co.

Course Title: Accelerator and Plasma
Paper Code: PHY.710

L	T	P	Credits	Marks
4	0	0	4	100

Total Lectures: 60

Course Objective: The objective of the course on Nuclear and Particle Physics is to teach the students the basic of nuclear properties, nuclear interactions, nuclear decay, nuclear models, detectors, nuclear reactions and elementary particles.

Unit: 1 **(15)**

Accelerators: Motion of charged particles in electric and magnetic fields, axial and radial magnetic field distributions in dipole, quadrupole and hexapole arrangement, Equipotential lines in different electrodes arrangement, Particle trajectory in electric and magnetic field, Electron sources, ion sources, Van de Graaf generator, DC linear accelerator, RF linear accelerator, Cyclotron, Microtone, introduction to advance accelerator (LHC)

Unit: 2 **(15)**

Detectors: Relation detectors Gaseous ionization, ionization and transport phenomena in gases, proportional counters, organic and inorganic scintillators, detection efficiency for various types of radiation, photomultiplier gain, semiconductor detectors, surface barrier detector, Si(Li), Gel(Li) and HPGe detectors.

Unit: 3 **(15)**

Plasma: Introduction to Plasma, Properties of low and high temperature plasma, plasma parameters (electron density, ion density, electron temperature, ion temperature, ion velocity, Debye length etc), Types of Plasma, Radio-frequency (RF) discharges: Capacitive RF discharge, Inductive RF discharge, Electron-cyclotron resonance (ECR) discharge, Dielectric barrier discharges, Atmospheric pressure plasmas, Magnetron discharge, Matching circuits and Applications.

Unit: 4 **(15)**

Electron/Laser Beam Interaction with Plasma: Plasma wake field acceleration, Drive beam, Tailor Beam, Plasma density, Plasma length, Plasma frequency, linear regime, blowout regime, Laser wake field acceleration.

Recommended books

1. Helmut Wiedemann, "*Particle Accelerator Physics" Springer* Publications 1994.
2. Rudolf Bock Angela Vasilescu "*The Particle Detector Accelerator Physics''* 1998th Edition.
3. Goldston, Robert J., and Paul Harding Rutherford. "*Introduction to plasma physics"*. CRC Press, 1995.
4. Bittencourt, José A. "*Fundamentals of plasma physics"*. Springer Science & Business Media, 2013.
5. Bellan, Paul M. "*Fundamentals of plasma physics"*. Cambridge University Press, 2008**.**