CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Ph.D. in Physics

Session 2020

Department of Physical Sciences

School of Basic and Applied Sciences

Learning Outcomes of the Programme:

The students will be able to:

- have knowledge and advanced research skills to carry out theoretical and experimental research in the various area of physics.
- Use available techniques, methods of analysis of data, interpretations and applications to the research work.
- Facilitate the specialized knowledge by inculcating the relevant attitudes and values required for undertaking quality research.

Course Structure

S. No.	Paper Code	Course Title	L	T	P	Cr
1	PHY.701	Research Methodology	4	0	0	4
2	PHY.751	Research and Publication Ethics	2	0	0	2
3	PHY.703	Statistics and Computer Applications	2	0	0	2
Choose any TWO of the following courses #						
4	PHY.704	Condensed Matter Physics	4	0	0	4
5	PHY.705	Thin Film and Vacuum Techniques	4	0	0	4
6	PHY.706	Nanostructured Materials	4	0	0	4
7	PHY.707	Density Functional Theory and Applications	4	0	0	4
8	PHY.708	Energetic Materials and Storage Devices	4	0	0	4
9	PHY.709	Accelerator and Plasma	4	0	0	4
		Total Credits	**16**	**0**	**0**	**16**

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

L	T	P	Credits
4	0	0	4

Learning Outcomes:

- The course will introduce the students to basic concepts of research methods.
- The students will learn about the preparation of research plan, reading and understanding of scientific papers, scientific writing, research proposal writing, ethics, plagiarism, laboratory safety issues etc.
- The students will learn about the microscopic, imaging and characterization techniques.

Unit I **(14)**

General principles of research: Meaning and importance of research, Critical thinking, Formulating hypothesis and development of research plan, Review of literature, Interpretation of results and discussion.

Bibliographic index and research quality parameters: citation index, impact factor, h index, i10 index, etc. Research engines such as google scholar, Scopus, web of science, etc.

Unit II **(16)**

Scientific and Technical Writing: Technical & scientific writing: Technical & Scientific writing - theses, technical papers, reviews, electronic communication, and research papers, etc., Poster preparation and Presentation and Dissertation. Reference Management using various software's such as Endnote, reference manager, Refworks, etc. Communication skills – defining communication; type of communication; techniques of communication, etc.

Library: Classification systems, e-Library, Reference management, Web-based literature search engines..

Unit III **(14)**

Plagiarism: Plagiarism, definition, Search engines, regulations, policies and documents/thesis/manuscripts checking through softwares, Knowing and Avoiding Plagiarism during documents/thesis/manuscripts/ scientific writing.

Unit IV **(16)**

Intellectual Property Rights: Intellectual Property, intellectual property protection (IPP) and intellectual property rights (IPR), WTO (World Trade Organization), WIPO (World Intellectual Property Organization), GATT (General Agreement on Tariff and Trade), TRIPs (Trade Related Intellectual Property Rights), TRIMS (Trade Related Investment Measures) and GATS (General Agreement on Trades in Services), Nuts and Bolts of Patenting, Technology Development/Transfer Commercialization Related Aspects, Ethics and Values in IP.

Suggested Readings:

1. Gupta,S. (2005). *Research Methodology and Statistical techniques.* New Delhi, India: Deep and Deep Publications (P) Ltd.
2. Kothari, C. R. (2008). *Research Methodology*. New Delhi, India: New Age International.
3. Haugstad, G. (2012). *Atomic Force Microscopy: Understanding Basic Modes and Advanced Applications:* John Wiley & Sons, Sussex, U.K.
4. Murty B.S, Shankar P., Raj B., Rath B. B., and Murday J., (2013). New York, USA: *Textbook of Nanoscience and Nanotechnology:* Springer.
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.

Transaction Mode: Class room teaching, and practical sessions.

Course Title: Research and Publication Ethics

Paper Code: PHY.751

Total Lectures: 30

L	T	P	Credits
2	0	0	2

Learning Outcomes: The students will able to

- Aware about the publication ethics and publication misconducts.
- Explain philosophy of science and ethics, research integrity, and publication ethics.
- Identify research misconduct and predatory publication based on hands-on-sessions.
- Outline indexing and citation databases.
- Make use of open access publications, research metrics (citation, h-index, impact Factor, etc.) and plagiarism tools.

Unit I **(8)**

Philosophy and Ethics: Introduction to philosophy: definition, nature and scope, concept, branches, Ethics: definition, moral judgments and reactions.

Scientific Conduct: Ethics with respect to science and research, Intellectual honesty and research integrity, scientific misconducts: Falsifications, fabrication, and plagiarism (FFP), redundant publications: duplicate and overlapping publications, salami slicing, Selective reporting and misrepresentation of data

Unit II **(7)**

Publication Ethics: Publication ethics: definition, introduction and importance, Best practices/standards setting initiatives and guidelines: COPE, WAME, etc., Conflicts of interest, Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types, Violation of publication ethics, authorship and contributor ship, Identification of publication misconduct, complaints and appeals, Predatory publishers and journals.

Unit III **(8)**

Open Access Publishing: Open access publications and initiatives, SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies, Software tools to identify predatory publication developed by SPPU, Journal finder/journal suggestion tools viz. JANE, Elsevier journal finder, Springer journal Suggester, etc.

Publication Misconduct: Group Discussions: Subject specific ethical issues, FFP, authorship, Conflicts of interest, Complaints and appeals: examples and fraud from India and abroad, Software Tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools.

Unit IV **(7)**

Databases and Research Metrics: Databases: Indexing databases, Citation databases: Web of Science, Scopus, etc., Research Metrics: Impact Factor of journal as per journal Citation Report, SNIP, SJR, IPP, Cite Score, Metrics: h-index, g index, i10 index, altmetrics.

Transaction Mode: Class room teaching, guest lectures, group discussions, and practical sessions.

Course Title: Statistics and Computer Applications
Paper Code: PHY.703
Total Lectures: 30

L	T	P	Credits
2	0	0	2

Learning Outcomes: The students will be able to

- Explain the basic concepts of data analysis.
- Discuss errors and uncertainty, various types of distributions, least square fitting etc.
- Apply MATLAB language to solve the numerical problems.

Unit I **(6)**

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

Unit II **(7)**

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 **(8)**

Least Square Fitting: Least-square fitting to a straight line by minimizing x^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: x^2 test for goodness of fit, Linear-correlation coefficient, Multivariable correlations, Confidence intervals, Monte Carlo tests.

Unit IV **(9)**

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.

Suggested Readings:

1. Guest P. G., (2012). *Numerical Methods of Curve Fitting* Cambridge, U. K : Cambridge University Press.
2. Kotulski Z. A. and Szczepinski W.,(2010). *Error Analysis with Applications in Engineering* New York, USA: Springer.
3. Vore J. D.(2012). *Probability and Statistics for Engineering and Sciences* New Delhi, India : Cengage Learning India Private Limited.
4. P. R. Bevington and D. K. Robinson.(2003). *Data Reduction and Error analysis for the Physical Sciences.* Noida, India : Tata McGraw Hill.
5. R. Pratap. (2010). *Getting Started with MATLAB.* Oxford, U. K: Oxford University Press.
6. Hunt B. R., Lipsman R. L., J. M. Rosenberg, *A Guide to MATLAB: For Beginners and Experienced Users* Cambridge, U. K :Cambridge University Press.
7. Otto S. and Denier J. P., (2005). *An Introduction to Programming and Numerical Methods in MATLAB.* New York, USA: Springer.

Transaction Mode: Class room teaching, and practical sessions.

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

L	T	P	Credits
4	1	0	4

Learning Outcomes: The students will able to

- Explain Fermi surfaces, their construction, and the experimental methods used for detection of fermi surfaces.
- Organize the various types of semiconductor, their theory and theory and applications of dielectrics and ferroelectrics.
- Explain plasmons, polaritons, polarons, color centres, excitons, Raman Effect and optical properties of solids.
- Analyze diffraction pattern of amorphous solids.
- Outline the theory of noncrystalline solids and Alloys.
- Explain theory and applications of magnetic materials.

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.

Suggested Readings:

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

Transaction Mode: Class room teaching, group discussions, and practical sessions.

Course Title: Thin Film and Vacuum Techniques	L	T	P	Credits
Paper Code: PHY.705	4	0	0	4

Total Lectures: 60

Learning Outcomes: The students will able to

- Outline the thin film deposition techniques.
- Explain optical, electrical, magnetic and mechanical properties and its applications.
- Summarise the 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.

Suggested Readings:

1. Murty B.S, Shankar P., Raj B ., Rath B .B., and Murday J. (2013). *Textbook of Nanoscience and Nanotechnology* New York, USA: Springer.
2. A. Kapoor. (2011). *An Introduction to Nanophysics and Nanotechnology.* New Delhi, India: Alpha Science International.
3. Seshan K., (2012). *Handbook of Thin Film Deposition Processes* (Elsevier, London, U. K.)
4. Gall D., Baker S. P. and Ohring M., (2013).*Materials Science of Thin Films: Deposition and Structure.* Massachusetts, USA : Academic Press.
5. Roth A. (1990). *Vacuum Technology.* New York, USA :Elsevier Science Publisher.
6. J.F. O'Hanlon, (1989). *A Users Guide to Vacuum Technology.* New York, USA: John Wiley & Sons.
7. J.M. Lafferty, (1998). *Foundations of Vacuum Science and Technology.* New York, USA : John Wiley & Sons.

Transaction Mode: Class room teaching, group discussions, and practical sessions.

Course Title: Nanostructured Materials

L	T	P	Credit

			s
4	1	0	4

Paper Code: PHY.706
Total Lectures: 60

Learning Outcomes: After completion of this course students would be able to

- Explain important role in the growing field of materials research.
- Discover innovative/smart modern materials.
- Explain nanomaterials and their properties.
- Explain synthesis via different methods/rout.
- Analyze different characterization tools that are used to probe the nanomaterials application/devices.

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.

Suggested Readings:

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

Transaction Mode: Class room teaching, group discussions, and practical sessions.

Course Title: Density Functional Theory and Applications

Paper Code: PHY.707

Total Lecture: 60

L	T	P	Credits
4	0	0	4

Learning Outcomes:

At the completion of course students will be able to:

- Explain the basics of Density Functional Theory (DFT).
- Apply the laws of quantum physics and the concepts of solid state physics to compute the properties of materials.
- Explain the details of density functional theory for electronic structure problems, pseudopotential approach, plane waves and localized orbitals basis sets methods.

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

Suggested Readings:

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

Transaction Mode: Class room teaching, group discussions, and practical sessions.

Course Tile: Energetic Materials and Storage

L	T	P	Credits

Devices

Paper Code: 708

Total Lectures: 60

4	0	0	4

Learning Outcomes: At the end of the course students would be able to

- Explain different materials use in development of solar cell
- Explain different materials use in development of Fuel Cell
- Explain different materials use in development of solar cell LED and Photovoltaic devices
- Explain different materials use in development of solar cell different Primary and Secondary Batteries
- Explain different materials use in development of super/ultracapacitors

Unit I **(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 II **(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 III **(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 IV **(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.

Suggested Readings:

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

Transaction Mode: Class room teaching, group discussions, and practical sessions.

Course Title: Accelerator and Plasma
Paper Code: PHY.709

L	T	P	Credits
4	0	0	4

Total Lectures: 60

- **Learning Outcomes:**
- Students will design the electron/ion accelerators, Cyclotron, Microtone etc.
- Students will design the radiation detectors
- Students will explain the Plasma, plasma parameters such as electron/ion density and temperature, ion velocity, Debye length etc
- Students will find the importance of Plasma wake field acceleration

Unit I **(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 II **(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 III **(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 IV **(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.

Suggested Readings:

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

Transaction Mode: Class room teaching, group discussions, and practical sessions.