Pre-Ph.D. (Physics)		Contact Hrs			Marks			Credits
Subject Code	**Subject Name**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
MREM0-101	Research Methodology	4	0	0	40	60	100	4
PPHY-101	Research and Computational Techniques Lab.	0	0	4	60	40	100	2
PPHY-102	Seminar	0	0	2	40	60	100	1
Departmental Electives (Choose any two subjects)		2x4	0	0	2x40	2x60	2x100	2x4
PPHY-103	Mathematical Tools							
PPHY-104	Radiation Protection and Dosimetry							
PPHY-105	Experimental Techniques in Nuclear and Particle Physics							
PPHY-106	Material Characterization Techniques							
PPHY-107	Vacuum Science and Thin Films							
PPHY-108	Environmental Physics							
PPHY-109	Modelling and Simulation Techniques							
Total		**12**	**0**	**6**	**220**	**280**	**500**	**15**

RESEARCH METHODOLOGY

Subject Code: MREM0-101 **L T P C** **Duration: 45 Hrs.**
4 0 0 4

UNIT–I (11 Hrs.)

Introduction to Research: Meaning, Definition, Objective and Process.
Research Design: Meaning, Types - Historical, Descriptive, Exploratory and Experimental.
Research Problem: Necessity of Defined Problem, Problem Formulation, Understanding of Problem, Review of Literature.
Design of Experiment: Basic Principal of Experimental Design, Randomized Block, Completely Randomized Block, Latin Square, Factorial Design.
Hypothesis: Types, Formulation of Hypothesis, Feasibility, Preparation and Presentation of Research Proposal.

UNIT–II (10 Hrs.)

Sources of Data: Primary and Secondary, Validation of Data
Data Collection Methods: Questionnaire Designing, Construction.
Sampling Design & Techniques – Probability Sampling and Non Probability Sampling.
Scaling Techniques: Meaning & Types.
Reliability: Test – Retest Reliability, Alternative Form Reliability, Internal Comparison Reliability and Scorer Reliability.
Validity: Content Validity, Criterion Related Validity and Construct Validity.

UNIT–III (13 Hrs)

Data Process Operations: Editing, Sorting, Coding, Classification and Tabulation.
Analysis of Data: Statistical Measure and Their Significance, Central Tendency, Dispersion, Correlation: Linear and Partial, Regression: Simple and Multiple Regression, Skewness, Time series Analysis, Index Number.
Testing of Hypothesis: T-test, Z- test, Chi Square, F-test, ANOVA.

UNIT – IV (11 Hrs.)

Multivariate Analysis: Factor Analysis, Discriminant Analysis, Cluster Analysis, Conjoint Analysis, Multi-Dimensional Scaling.
Report Writing: Essentials of Report Writing, Report Format.
Statistical Software: Application of Statistical Softwares like SPSS, MS Excel, Mini Tab or MATLAB Software in Data Analysis.
**Each Student has to Prepare Mini Research Project on Topic/ Area of their Choice and Make Presentation. The Report Should Consists of Applications of Tests and Techniques Mentioned in The Above UNITs*

Recommended Books:

1. R.I. Levin and D.S. Rubin, 'Statistics for Management', 7th Edn. Pearson Education New Delhi.
2. N.K. Malhotra, 'Marketing Research – An Applied Orientation', 4th Edn., Pearson Education New Delhi.
3. Donald Cooper, 'Business Research Methods', Tata McGraw Hill, New Delhi.
4. Sadhu Singh, 'Research Methodology in Social Sciences', Himalaya Publishers.
5. Darren George & Paul Mallery, 'SPSS for Windows Step by Step', Pearson Education, New Delhi

6. C.R. Kothari, 'Research Methodology Methods & Techniques', 2nd Edn., New Age International Publishers.

RESEARCH & COMPUTATIONAL TECHNIQUES LAB.

Subject Code: PPHY-101 **L T P C** **Duration: 48 Hrs.**
0 0 4 2

Computational Techniques:
Introduction to Numerical Methods, Programming Languages Fortran 95 or C++, Use of the programming language to design the programs assigned by the supervisor with the consent of the Head of the Department.
Introduction to Latex and Origin and their applications.
Experimental Tools:
As per the requirement of the research topic.

SEMINAR

Subject Code: PPHY-102 **L T P C** **Duration: 24 Hrs.**
0 0 2 1

The Pre-PhD course work candidate will do literature review of minimum 10 research paper of reputed journals related to the research field and will finally present the seminar.
The Pre PhD course work candidate will submit 3-4 topics out of which one topic will be approved by a committee at the departmental level. The student has to do literature review of minimum 10 research paper of that topic of reputed journals and will finally present the seminar.
Evaluation: Satisfactory/Unsatisfactory by a committee of three faculty member including head of the department.

MATHEMATICAL TOOLS

Subject Code: PPHY-103 **L T P C** **Duration: 45 Hrs.**
4 0 0 4

UNIT- 1

Numerical Techniques: (12 Hrs.)
Introduction to numerical techniques, Solution of equations graphically, Newton's Raphson's method or Successive substitution method, Rules of false position, Interation method or indirect method, Solution of linear systems, Jacobi's method, Gauss-Seidal method, Taylor series method, Euler's method, Runga Kuta Method.

UNIT- 2

Group Theory: (12 Hrs.)
Definition of a group, Composition table, Conjugate elements and classes of groups, directs product, Isomorphism, homeomorphism, permutation group, Definitions of the three dimensional rotation group and SU (2), O (3).

UNIT- 3

Sampling and Probability Distribution: (12 Hrs.)

Random Variables: Definition, Probability Distribution-Binomial, Poisson and Normal distributions. Sampling Distributions: Population and samples, Concept of sampling Distributions-Student's t test, F-test and Chi-square test, Curve Fitting, Least square fitting.

UNIT- 4

Tensors: (12 Hrs.)

Review of tensor, Equality of Tensors - Symmetric and Skew – symmetric tensors - Outer multiplication, Contraction and Inner Multiplication - Quotient Law of Tensors - Reciprocal Tensor of Tensor - Relative Tensor - Cross Product of Vectors, Riemannian Space - Christoffel Symbols and their properties.

Recommended Books:

1. S.C. Gupta & V.K. Kapoor, 'Mathematical Statistics', S. Chand.
2. Josaph A. Gallian, 'Contemporary Abstract Algebra', Narosa.
3. A.R. Vasishtha, 'Modern Algebra', Krishna Prakashan.
4. Erwin Kreyszig, 'Advanced Mathematical Physics'.
5. J.L. Synge and A. Schild, 'Tensor Calculus', Toronto, **1949**.
6. H.K. Dass, 'Advanced Engineering Mathematics', S. Chand.

RADIATION PROTECTION & DOSIMETERY

Subject Code: PPHY-104 **L T P C** **Duration: 45 Hrs.**
4 0 0 4

UNIT--I

Radiations and Dosimeter: (12 Hrs.)

Basic Concepts of Radiation and Dosimetric Units: Radiation & need for its measurements, physical features of radiations, conventional sources of radiation, tissue equivalent materials, radiation dose, Definition of dose quantities :- Fluence, kerma, exposure, absorbed dose, Dose equivalent, Quality factor Q, effective dose equivalent, determination of dose equivalent, Radiation quality.

UNIT– II

Radiation Physics Applications: (11 Hrs.)

Archaeological applications: Carbon dating; limitations and accuracy. Industrial Applications: Smoke detection, blockage/leakage detection of buried pipelines, thickness gauge, non-destructive testing. Agricultural Applications: benefits of radiation processing of food items, sterilization. Medical Applications: sterilization of medical equipment's, diagnosis and radiotherapy: in-vivo and in-vitro. Space Exploration: nuclear batteries/RTG. Practical applications and some simple numerical problems.

UNIT – III

Measurement of Radiation Dose: (11 Hrs.)

Measurement of Radiation Dose: Thermo-luminescent dosimetry (TLD):- Theoretical aspects of thermos-luminescence, Characteristics of TL dosimeters, commercial TLD dosimeters, - LiF, $Li_2B_4O_7$, $CaSO_4$, MgB_4O_7.,TLD instrumentations, Applications of TLD. An introduction to Photoluminescence (PL), Solid state Nuclear Track dosimetry, Internal dosimetry, External dosimetry.

UNIT-– IV

Radiation Effects & Protection: (11 Hrs.)

Effects of radiations exposure, Biological effects of radiation, acute and delayed effects, stochastic and non-stochastic effects, Dose response characteristics, Relative Biological Effectiveness (RBE). History of radiation protection standards, current limits of radiation exposure, protective barriers for radiation sources, protection for sealed sources, radiation surveys, personal monitoring. Permissible dose to occupational and non-occupational workers, safe handling of radioactive materials. ALARA, ALI and MIRD concepts, Radiation waste and its disposal.

Recommended Books:

1. G.F. Knoll, 'Radiation Detection and Measurement', 3rd Edn., John Wiley & Sons Inc., **2000**.
2. E.B. Podgorsak, 'Radiation Physics for Medical Physicists', Springer, **2006**.
3. R.M. Singru, 'Introduction to Experimental Nuclear Physics', Wiley Eastern Pvt. Ltd., **1974.**
4. S.N. Ahmed, 'Physics and Engineering of Radiation Detection', Academic Press, **2007**.

EXPERIMENTAL TECHNIQUES IN NUCLEAR AND PARTICLE PHYSICS

Subject Code: PPHY-105 **L T P C** **Duration: 45 Hrs.**

4 0 0 4

UNIT-I

Detection of Radiations: (11 Hrs.)

Interaction of gamma-rays, electrons, heavy charged particles, neutrons, neutrinos and other particles with matter. General properties of Radiation detectors, energy resolution, detection efficiency and dead time. Gas-filled detectors, Proportional counters, space charge effects, energy resolution, time characteristics of signal pulse, position-sensitive proportional counters, Multiwire proportional chambers, Drift chamber, Organic and inorganic scintillators and their characteristics.

UNIT-II

Electronics Associated with Detectors: (14 Hrs.)

Electronics for pulse signal processing, CR-(RC)n and delay-line pulse shaping, pole-zero cancellation, baseline shift and restoration, preamplifiers (voltage and charge-sensitive configurations), overload recovery and pileup, Linear amplifiers, single-channel analyzer, analog-to-digital converters, multichannel analyzer. Basic considerations in time measurements, Walk and jitter, Time pickoff methods, time-to amplitude converters, Systems for fast timing, fast-slow coincidence, and particle identification, NIM and CAMAC instrumentation standards and data acquisition system.

UNIT-III

Experimental Methods in Nuclear Physics: (10 Hrs.)

Detector systems for heavy-ion reactions: Large gamma and charge particle detector arrays, multiplicity filters, electron spectrometer, heavy-ion reaction analyzers, nuclear lifetime measurements (DSAM and RDM techniques), production of radioactive ion beams.

UNIT-IV

Experimental Methods in Particle Physics: (10 Hrs.)

Detector systems for high energy experiments: Collider physics (brief account), Particle Accelerators (brief account), Secondary beams, Beam transport, Modern Hybrid experiments-

LHS, CMS and ALICE.

Recommended Books:

1. Richard Fernow, 'Introduction to Experimental Particle Physics', Cambridge University Press, **2001**.
2. Glenn F. Knoll, 'Radiation Detection and Measurement', Wiley, **2010**.
3. W.R. Leo, 'Techniques in Nuclear and Particle Experiments', Springer, **1994**.
4. Konrad Kleinknecht, 'Detectors for Particle Radiation', Cambridge University Press, **1999**.

MATERIAL CHARACTERIZATION TECHNIQUES

Subject Code: PPHY-106 **L T P C** **Duration: 45 Hrs.**
4 0 0 4

UNIT-I

Magnetic Measurements: (8 Hrs.)

Magnetometry: Vibrating Sample Magnetometery, Thermomagnetic Analysis, Superconducting quantum interference device (SQUID), Spintronic measurements.

UNIT-II

X-Ray Techniques: (13 Hrs.)

XAFS and XANES Spectroscopy, X-Ray Magnetic Circular Dichroism, Single crystal and powder x-ray diffraction, X-Ray Diffraction Techniques for Liquid Surfaces and Monomolecular Layers, Small-angle X-ray scattering (SAXS). Inelastic x-ray scattering, Synchrotron radiation sources: advantages and special features of synchrotron radiation.

UNIT-III

Neutron Scattering Techniques: (12 Hrs.)

Neutron Powder Diffraction, Single-Crystal Neutron Diffraction, Magnetic Neutron Scattering, Small-angle neutron scattering (SANS), Phonon and dynamics studies by inelastic and quasielastic neutron scattering. Neutron reflectometry for thin films.

UNIT-IV

Microscopy: (12 Hrs.)

Optical, polarizing and confocal microscopy, Scanning Electron Microscopy (SEM) and Transmission electron microscopy (TEM). Elemental analysis by Energy dispersive and wavelength dispersive X-ray analysis. Sample preparation for TEM by ion milling and shadow techniques. AFM and STM: Basic principles and different modes of operation. Magnetic Force Microscopy (MFM).

Recommended Books:

1. John Clarke and Alex I. Braginski, 'The SQUID Handbook: Fundamentals and Technology of SQUID and SQUID Systems', Wiley-VCH, **2004**.
2. 'Solid State Magnetism', John Crangle, Edward Arnold – UK, **1991.**
3. J. Daillant and A. Gilaud, 'X-ray and Neutron Reflectivity', Springer, **2009**.
4. T.L. Alfard, L.C. Feldman and J.W. Mayer, 'Fundamentals of Nanoscale Film Analysis', Springer, **2007**.
5. R. F. Egerton, 'Physical Principles of Electron Microscopy: An Introduction to TEM, SEM and AEM', Springer, **2005**.
6. S. Zhang, L. Li and A. Kumar, 'Materials Characterization Techniques', CRC Press, **2009**.

VACUUM SCIENCE AND THIN FILMS

Subject Code: PPHY-107 **L T P C** **Duration: 45 Hrs.**
4 0 0 4

UNIT-I

Behaviour of Gases: (10 Hrs.)
Mean free path, particle flux, monolayer formation, Gas laws. Elementary Gas Transport Phenomenon: Viscosity, diffusion, and thermal transpiration. Gas Flow: gas throughput, conductance, mass flow, viscous and molecular flow regimes, transition regime.

UNIT-II

Measurement of Pressure: (10 Hrs.)
Thermal conductivity Gauge, Penning gauge, Ionization Gauge, Bayard-Alpert Gauge, Residual Gas Analyzer. Production of Vacuum: Mechanical pumps (Rotary, Root and Turbomolecular pumps), Diffusion pump, Getter and Ion pumps, Cryopumps.

UNIT-III

Physical Vapor Deposition (12 Hrs.)
Hertz Knudsen equation; mass evaporation rate; Directional distribution of evaporating species Evaporation of elements, compounds, alloys, e-beam, pulsed laser and ion beam evaporation, Glow Discharge and Plasma, Sputtering - mechanisms and yield, DC and RF sputtering, Bias sputtering, magnetically enhanced sputtering systems, reactive sputtering, Hybrid and Modified PVD-Ion plating, reactive evaporation, ion beam assisted deposition.

UNIT-IV

Chemical Vapor Deposition (13 Hrs.)
Reaction chemistry and thermodynamics of CVD; Thermal CVD, laser & plasma enhanced CVD, Chemical Techniques - Spray Pyrolysis, Electrodeposition, SolGel and LB Techniques, Nucleation & Growth: capillarity theory, atomistic and kinetic models of nucleation, basic modes of thin film growth, stages of film growth & mechanisms, Epitaxy - homo, hetero and coherent epilayers, lattice misfit and imperfections, epitaxy of compound semiconductors.

Recommended Books:

1. Marsbed H. Hablanian, 'High Vacuum Technology – A Practical Guide', Marcel Dekker, Inc., New York, **1990**.
2. John F. O'Hanlon, 'A User's Guide to Vacuum Technology', John Wiley & Sons, New York, **1989**.
3. A. Roth, 'Vacuum Technology', Pergamon Press Ltd., Oxford.
4. A Chambers, R.K. Fitch & B.S. Halliday, 'Basic Vacuum Technology', Int. of Phys. Publishing, Bristol & Philedelphia, **1998**.
5. L.I. Maissel and R. Glang, 'Hand Book of Thin Film Technology', McGraw Hill Inc., **1970**.
6. K.L. Chopra, 'Thin Film Phenomena', McGraw Hill Inc., **1969**.
7. Milton Ohring, 'The Materials Science of Thin Films', Academic Press, **1992**.

ENVIRONMENTAL PHYSICS

Subject Code: PPHY-108 **L T P C** **Duration: 45 Hrs.**
4 0 0 4

UNIT-I

Introduction Environmental Physics: (11 Hrs.)

Concept and scope of environmental Physics with respect to human environment, Heat balance (steady and transient), Basics of transport of heat, mass, momentum and radiant energy, Natural and anthropogenic sources of pollution. Primary and Secondary Pollutants. Transport and diffusion of pollutants.

UNIT-II

Atmosphere and Meteorological Impacts: (11 Hrs.)

Structure and composition of atmosphere: Large scale vertical structure of the atmosphere, composition of the atmosphere, Different layers of atmosphere, their characteristics and temperature relationships; Atmospheric stability, inversions and mixing heights, wind roses Residence time, Photochemical pollution, Atmospheric aerosol, Meteorology: Weather and Climate, Atmospheric general circulation, Air mass and weather fronts, Weather elements, Precipitation and types of storms.

UNIT- III

Sampling and Monitoring Environmental Matrices (12 Hrs.)

Air/water/soil pollution Sampling and Monitoring: Scope, Purpose and Objectives of Air/water/soil Quality Monitoring Programme; Preliminary information required for planning quality survey; Guidelines for planning a survey; Design of quality surveillance network; Period, frequency and duration of sampling; Averaging times; Sample size determination; Principles and instruments for measurement of pollutants. Computer applications in environmental modelling. Computer-based modelling: Linear, regression, validation and forecasting.

UNIT-IV

Instrumentation and Analytical Methods (11 Hrs.)

Instrumentation and analytical methods involved in the following techniques and their applications in environment: Fluorescence Spectroscopy, Visible, Atomic and Infrared spectrometry, Flame photometry, Atomic Absorption Spectroscopy (AAS), X-ray diffraction (XRD), X-ray fluorescence (XRF), Mass Spectroscopy, Neutron Activation Analysis (NAA), Inductive Coupled Plasma (ICP-MS), Particle Induced X-ray Fluorescence (PIXE).

Recommended Books:

1. W.P. Cunningham and M.A. Cunningham, 'Principles of Environment Science Enquiry and Applications'. 2nd Edn., Tata McGraw Hill, New Delhi, **2004**.
2. M. Dzelalija, 'Environmental Physics', University of Split, **2004**.
3. S.K. Bhargava, 'Practical Methods for Water and Air Pollution Monitoring', New Age International Pub., New Delhi, **2008**.
4. J. Monteith and M. Unsworth, 'Principles of Atmospheric Physics.', 3rd Edn., Academic Press, Inc., USA, **2007**.

MODELING & SIMULATION TECHNIQUES

Subject Code: PPHY-109 **L T P C** **Duration: 45 Hrs.**
4 0 0 4

UNIT-I

Introduction to Modelling & Simulations: (11 Hrs.)
Introduction: modelling and simulations, Different types of simulation, Concept of a system, Continuous and Discrete systems, System modelling, Types of models, Progress of a simulation study, Monte Carlo method, comparison of Simulation and analytic methods, Numerical computational techniques for discrete and continuous models.

Simulation Languages and Applications of Simulation: (12 Hrs.)
Simulation language features, Hardware requirements, Use of simulation, Simulation as a designed tool, Estimation of Simulation time. Methodology for manufacturing simulations, Forcing completion of design with simulation, the simulation decision, Optimizing and developing solutions, Genetic Algorithms, Ethics in simulation.

Simulation Development and Implementation: (11 Hrs.)
Quality Assurance Phase, Selection of a language or tool, Model construction and verification, Experimental Design, Production runs, Output analysis and Reporting, Post Processing Output, Operations, Maintenance and Archival Phase.

Simulation Models: (11 Hrs.)
Discrete Event simulation, Continuous simulation, Computer model of Queuing, inventory and scheduling systems, Parallel Simulations, Simulation and data dependency, Performing verification and validation.

Recommended Books:

1. John A. Sokolowski and Catherine M. Banks, 'Principles of Modelling and Simulation - A Multidisciplinary Approach', Wiley.
2. Louis G. Birta Gilbert Arbez, 'Modelling and Simulation - Exploring Dynamical System Behaviour', Springer.
3. Bernard P. Zeigler, Tag Gon Kim, 'Theory of Modelling and Simulation - Integrated Discrete events and Continuous Complex Dynamic Systems', Herbert praehofer.