Syllabus for

PhD Course Work

2015

Department of Physics

Rajiv Gandhi University

Rono Hills, Doimukh-791112

Arunachal Pradesh, INDIA

PHYD-701: Research methodology and Computational Techniques

1. Basics of scientific research: Definition of Research, Characteristics, types, needs of research, qualities of Researcher, Components of a Research Problem, and Differences between Methods of Research &Research Methodology. Motivation for Research, Research approaches and RelatedTools, Conditions and criteria for good research. Various Steps in Scientific Research: Hypotheses, Research Purposes, Research Design, Literature survey, sources of information, review. Objectivity,Ethical issues and intellectual property rights, Patent laws, process of patenting a research finding, Copy right,

2. Developing a research plan and Literature survey: Aims and Objectives,information required for solving the problem, defining each major concept in operational terms: an overall description of approach, clearly stating any assumptions; details of techniques. Expected outcome, Methodology to be adapted, planning of experiments for achieving the aims and objectives, reproducibility of research work.Literature survey of the previous works Review of an article in the relevant field and preparation of a short reportReferences, Abstraction of a research paper, possible ways of gettingoneself abreast of current literature.

3. Data Collection and Processing: Sources, acquisition and interpretation of data, Qualitative and quantitative data, Experimental data, field data, data from other sources. Dataprocessing,Graphical representation and mapping of data.Data analysis - Sampling: types, steps involved in sampling, sample size, advantages and limitations.Sources of Data: Primary Data, Secondary Data; Sampling Merits andDemerits of Experiments, Procedure and Control Observations, Sampling Errors - Type-I Error - Type-II Error.

4. Research report and Presentation: Art of scientific writing: Steps to better writing, flow method, organization of material and style, Structure and Components of Research Report, Types of Report: research papers, thesis. Research Project Reports, Drawing figures, graphs, tables, footnotes, references etc. in a research paper. Writing of research report and synopsis (steps involved), paper writing (steps involved), review writing, report preparation, publication process, selection of journals, citation index, impact factor, h-index.Presenting a paper in scientific seminar (oral/ poster) development of communication skills in presentation of scientific seminars- eye to eye contact, facing to audience, question & answer sessions etc.

5.Computational Techniques in Research: Computer fundamental- word processing, spreadsheet and database software. Use of internet and internet networks in research activities - Literature survey, handling search engines, paper downloading, Email, relevant websites for journals and arXives, Accessing research databases (SciFinder, Scopus, Cambridge Structural Database (CSD), SPIRES database, Cyber laws. Statistical analysis and fitting of data in computer, Computer usage for collecting/analyzing data – Mathematical and statistical analysis using software tools like MAT Lab, SPSS, PsiLAB or free ware tools, simulations through software and programming (fortran/ C/ Mathematica/ Matlab/Mathcad)

PHYD-702: Physics of Advance Materials

1. Fundamental of Advance Materials: Free electron energy levels, Bloch theorem, Kroing-Penney model, The nearly free electron approximation, The tight binding approximation, energy bands semiconductors and concentration of charge carriers in the bands, fermi surface and its characteristics, Various other methods for calculating band structure. The basic Hamiltonian in solid, Reduction to one electron problem for determining bands in solids (single particle approximation) - Variational principle, Hartree approximation, Hartee-Fock approximation, Density functional approximation, Hohenberg-Kohn Theorem; Kohn-Sham Equation; Thomas-Fermi approximation, Practical DFT in a many body calculation and its reliability.

2.Low Dimension Materials: Quantum confinement and Electronic structure, Metallic and Non- mettallic nanostructures, surface plasmon resonance, Surface Plasmon Polariton, Carbon based nanomaterial (Fullerene,Carbon nanotubes, graphine etc), Magnetic Nanomaterials. Superparamagnetic materials, spintronics, spin valve, magnetic tunnel junction, Quantum Transport in nanostructures-Ballistic transport, Phase coherence, Aharonv-Bohm effect, quantized conductance, Landauer formula, quantum point contact, Landauer Buttiker formula for multileads, coulomb blockage, SET, molecular electronics, Kondo effect in nanostructures. Application of nano materials.

3. **Soft Condensed Materials:** various types of soft matters (liquid crystal, colloidal systems, biologicalmembranes, macromolecules),mesophase and their molecular theories, Symmetry and order parameter, Landu's theory of phase transition. Dispersion colloids: stability and forces, DLVO theory, gels, emulsions and foams, amphiphiles, micells – critical micelle concentration, colloids in biological systems, Biological membranes and theirs properties (bilayer), Phase diagram. Macromolecules : DNAs, Flory's model of DNA condensation, Polymorphism of liquid crystal states by low molecular mass double stander DNA compels, DNA condenstation.

4. **Surfaces and interfaces**: Surfaces in Materials and its structure, Energies of surfaces, simple surface relaxation, Electronic surface structure, surface charge density, Surface cleaving and interaction of gases with surfaces, Adsorption on surface: physisorption, chemisorption, Langmuir Blodgett films, Crystal face dependence, charge density effects from chemisorption,

5. Synthesis and Characterization of Advance Materials: Various synthesis and processing techniques of materials. Sol-gel, Chemical Bath, Ball milling, Physical Vapour deposition: Thermal, Spray prolysis, Sputtering, pulsed Laser, ALD and MBE , Chemical Vapour Deposition: PECVD, CVD **Characterization of materials:** X-ray diffraction, XRF, Chemical analysis by XRF, small angle x-ray diffraction, Electron Microscopy (SEM,TEM, HRTEM), Scanning probe microscopy (AFM, MFM, STM), UV-Vis, spectroscopy, FT-IR spectroscopy, Luminescence spectroscopy techniques- Fluorescence spectroscopy, Raman spectroscopy, DTA, TGA, DSC; Electronic transport analysis using Current vs Voltage characteristics – two probe and four probe techniques - various types of contacts, Dielectric and impedance spectroscopy, spectrum analyzer, SQUID, fluorescence, Surface characterization techniques: LEED, PES, AES, SIMS, EXAFS.