Indira Gandhi National Tribal University, Amarkantak (M.P.) - 484 887

(A Central University Established by an Act of Parliament)

SYLLABUS

(Based on CBCS Pattern)

Department of Physics
(Faculty of Science)

Ph.D. Program in Physics

(Effective from 2018-2019)

ABOUT THE PROGRAM

The PhD course work comprises common courses (05 credits: **A**), discipline- specific courses (05 credits: **B**) and research theme-specific courses (05 credits: **C**). Since the PhD students come from different educational backgrounds, relevant courses will be chosen in consultation with the concerned DRC/RPC to compliment the previous education, improve specific skills required for thesis and subsequent career. The *Common Courses (SCC)*, for all PhD scholars registered in Physical sciences related disciplines with the Faculty of Science; IGNTU, and *Discipline-Specific Courses* designed for e.g., Physics (e.g., PHTD), are compulsory for all. Whereas, a research scholar will choose elective courses (i.e., *Research Theme - Specific Courses,* PHTR) as suggested by the concerned DRC/RPC. Evaluation of the research plan proposal and presentation, and review of literature will be done by the concerned DRC/RPC. The detailed course layout is given below.

COURSE LAYOUT

A) Common Courses (05 credits)

Course Code	Title	Nature	Credits
SCC-01	Research Methodology	Compulsory	**04**
SCC-02	Lab. work based on SCC-01	Compulsory	**01**

B) Discipline-Specific Courses (05 credits)

Course Code	Title	Nature	Credits
PHYD-01	Instrumentation & Experimental Techniques	Compulsory	**04**
PHYD-02	Lab. work based on PHYD-01	Compulsory	**01**

C) Research Theme-Specific Courses (05 credits)

Course Code	Title	Nature	Credits
Any one of the following -		Elective	**03**
PHYR-01	Structural Characterization and Optical Properties of Materials		
PHYR-02	Nano Fabrication and Characterization		
PHYR-03	Introduction to Quantum field theory		
PHYC-01	Review of literature and presentation of a seminar on a research theme related topic approved by concerned DRC/RPC.	Compulsory	**02**
Total credit (A+B+C)			**15**
Duration of the entire course	06 Months (i.e., one semester)		

DETAILED COURSE CONTENTS

A) Common Courses (05 credits)

SCC-01: Research Methodologies **Credits: 04**

a. **An overview of research methodology:** Research concept, steps involved, identification, selection and formulation of research problem, justification, hypothesis; literature collection- textual and digital resources (internet).
b. **Research design, data collection and interpretation:** Research design; sampling techniques, collection and documentation, presentation, analysis and interpretation of data.
c. **Scientific writing:** Forms of scientific writing- Article, notes, reports, review article, monographs,dissertations,popularsciencearticles,bibliographies,
d. **Formulation of scientific communication**: Outline preparation, drafting title, sub titles, tables, illustrations; Formatting tables- title, body footnotes; figures & graphs- structure, title and legends, Impact factor, citation indices, plagiarism.
e. **Computer application:** MS office, excel, power point, Origin, imageJ, WSxm, Match, XPowder, Fullprof, Diamond, Labview, MATLAB, MATHEMATICA.

Suggested Readings:

1. Research Methodology - Methods & Techniques, CR Kothri CR (1990), VishvaPrakashan, NewDelhi.
2. Research Methodology & Statistical Techniques, S Gupta (1999) Deep & Deep Publications, NewDelhi.
3. Research Methodology for Biological Sciences, N Gurumani (2007), MJP Publishers, Chennai.
4. Research Design:Qualitative, Quantitative &Mixed Method Approaches, JohnW. Creswell (2009), Sage Publication, USA.

SCC-02: Lab work basedonSCC-01 **Credits: 01**

B) Research Theme-Specific Courses (05 credits)

PHYD-01 Instrumentation & Experimental Techniques **Credits: 03**

X-ray diffraction by Crystals, Braggs Law, X-ray Diffraction (XRD): powder and single crystal Diffraction, X-ray fluorescence (XRF), X ray photoelectron spectroscopy (XPS), Energy Dispersive X-ray analysis (EDS).

Electron Spin Resonance (ESR), Nuclear Magnetic Resonance (NMR) and Raman spectroscopy: description and analysis. Surface analysis methods: Secondary ion mass spectroscopy (SIMS), Auger Electron Spectroscopy, ESCA, Deep Level Transient Spectroscopy (DL TS).
Thermal Analysis: Thermo Gravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC), Differential Thermal Analysis (DTA).Electron Energy Loss Spectroscopy (EELS), Electron Probe Micro Analyzer (EPMA).

Microscopy: Optical Microscopy, Electron Microscopy, Scanning Electron Microscopy, Field Emission Scanning Electron Microscopy (FESEM) Scanning Tunneling Electron Microscopy (STEM), Transmission Electron Microscopy (TEM), High Resolution Transmission Electron Microscopy (HRTEM), Contact and non contact Atomic Force Microscopy (AFM).

Spectrophotometer: UV-Vis spectrophotometers, IR spectrophotometers, Fourier Transform Infrared Radiation (FTIR), Photoluminescence (PL), Electroluminescence, Mechanoluminescence, Thermoluminescence spectroscopy (TL).

PHYD-01 Lab. work based on PHYD-01 Credits: 02

C) Discipline-Specific Courses (05 credits)

PHYR-01: Structural characterization and Optical Properties of Materials Credits: 03

Part A: Synthesis of Materials

Formation of nanostructures: Chemical Vapor Deposition (CVD), Physical Vapour Deposition (PVD), Pulsed Laser Ablation (PLD). Chemical Routes for synthesis of Nanomaterials and bulk Materials: Chemical precipitation and co-precipitation, chemical bath deposition (CBD), Sol-gel synthesis, Microemulsions or reverse micelles, Solvothermal synthesis, Thermolysis routes and spray pyrolysis, Combustion technique, solution combustion technique, Solid state reaction method.

Part B: Structural Characterization of Materials

Interpretation of Laue equations, Braggs Law, The Laue, Powder and Rotating crystal methods, X-ray Diffraction (XRD), X-ray Fluorescence (XRF), Energy Dispersive X-ray Analysis (EDS). Thermo Gravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC), Differential Thermal Analysis (DTA). Field Emission Scanning Electron Microscopy (FESEM), Transmission Electron Microscopy (TEM), Spectrophotometer: UV-Vis spectrophotometers, Fourier Transform Infra-red (FTIR) and Raman Spectroscopy.

Part C: Optical Properties of Materials

Spectrum of the rare earths, Luminescence, Phosphors: different kinds of phosphors Photoluminescence (PL): Commission International de I'Eclairage (CIE), Color purity, Co-related Color temeperature (CCT), Color Rending Index (CRI) and quantum efficiency afterglow. Thermoluminescence (TL), Mechanoluminescence (ML), Electroluminescence (EL).

Suggested Readings:

1. Handbook of Analytical instruments, R.S. Khandpur
2. X-ray diffraction procedures, H. P. Klung and L. E. Alexander
3. The Powder Method, Azaroff and M. J. Buerger
4. Thermal Methods of Analysis, W. W. Wendlandt
5. Encyclopedia of Nanotechnology, H.S. Nalwa
6. E.N. Harvey, A history of luminescence from the earliest times until 1900, The American Philosophical Society, Philadelphia, (1957).
7. Luminescent Materials, G. Blasse, B.C. Grabmailer.
8. Luminescence: From Theory to Application, C. Ronda,
9. Numerical and Practical Exercises in Thermoluminescence, V. Pagonis, G. Kitis, C. Furetta.

PHYR-02: Nano Fabrication and Characterization **Credits: 03**

Part A: Nano fabrication

1. Broad survey of the modern device technology
2. Review of basic device physics, MOS capacitor as a building block of FET, CMOS scaling, Non idealities in MOS structure, metal gate electrodes and work function engineering,
3. Growth of structures of high structural quality and multilayers of simple and comlex systems: Molecular Beam Epitaxy, Atomic layer Deposition, Pulsed Laser Ablation, Ion-assisted Ion-beam Deposition, Ion-implantation Inter-diffusion and Reactions in Thin Films, Diffusion during filmgrowth, Diffusion barriers.

Part B: Device and material characterization

1. Optical characterization: optical microscopy, thin film measurement, ellipsometry and Raman spectroscopy.
2. Electrical characterization: Resistivity with two probe, four probe and van der Pauw technique, Hall mobility, DC I-V and High frequency C-V characterization.
3. Material characterization: Scanning electron microscopy, Atomic force microscopy, XRD, XPS, and Focused ion beam machining

Part C: Emerging materials and technology

1. Graphene, Molybdenum disulfide (MoS_2), Tungsten disulfide (WS_2) and other twodimensional materials;
2. High-k gate dielectrics, Thin film transistors, Memory technology.

Suggested Readings:

1. O. Engstrom, The MOS System, Cambridge university press, Cambridge (2014).
2. K. Seshan, Handbook of thin film deposition processes and techniques, William Andrew Publishing Norwich, New York, USA (2002).
3. H. Fujiwara, Spectroscopic Ellipsometry Principles and Applications, John Wiley & Sons Ltd. (2007).
4. B. D. Cullity, Elements of X-ray diffraction, Addison-Wesley Publishing (1977).
5. T. L. Barr and Modern ESCA: The Principles and Practice of X-Ray Photoelectron Spectroscopy, Boca Raton, CRC Press (2008).
6. D. K. Schroder, Semiconductor material and device characterization, Wiley Interscience (2006).

PHYR-03: Introduction to quantum field theory **Credits: 03**

Classical Field Theory: Lorentz Invariance, Symmetries, The Hamiltonian Formalism, Free Fields, Canonical Quantization, Free Scalar Field, The Vacuum, Particles, Complex Scalar Fields, Heisenberg Picture, Propagators, Non-Relativistic Fields.

Interacting Fields: First Look at Scattering, Wick's Theorem, Feynman Diagrams, Examples of Scattering Amplitudes, Cross Sections and Decay Rates, Green's Functions.

The Dirac Equation: Spinor Representation, Chiral Spinors, Weyl Equation, Parity, Majorana Fermions, Symmetries and Conserved Currents, Plane Wave Solutions.

Quantizing the Dirac Field: Fermi-Dirac Statistics, Dirac's Hole Interpretation, Propagators, The Feynman Propagator, Yukawa Theory, Feynman Rules for Fermions.

Quantum Electrodynamics: Maxwell's Equations, Quantization of the Electromagnetic Field, Coupling to Matter, QED, Feynman Rules, Scattering in QED.

Suggested Readings:

1. An Introduction to Quantum Field Theory, Peskin and Schroeder (1995).
2. Quantum Field Theory in a Nutshell, A. Zee (2010)
3. Quantum Field Theory and the Standard Model, M. D. Schwartz (2013)
4. Quantum theory of fields. Foundations. Volume 1, S. Weinberg (1995)
5. Quantum field theory, M. Srednicki (2007)

PHYSC-01: Review of literature and presentation of a seminar on a research theme related topic approved by concerned DRC/RPC. **Credits: 02**

The syllabus of Ph.D. (Course Work) is hereby approved in a meeting of the Members of the Board of Study (BOS) for the Department of Physics, Indira Gandhi National Tribal University, Amarkantak, Madhya Pradesh, on this date of 30/07/2017.