Scheme and Syllabi for Ph.D. Course work in Physics
(Effective from the Session 2020-21)
Program Specific Outcomes of the Ph.D. Course Work (Physics)

PSO1: The grasp of research methodology enables the research scholars in designing, defining and formulation of research programs will the objectives stated therein.

PSO2: The contents in the program are designed in a manner to have a significantimprovement in analytical skills of the research scholars engaged in experimental work.

PSO3: In depth understanding of structural properties of materials as important in designing about the applications in different domains.

PSO4: The curriculum has been designed in a manner for detailed exposure of advanced characterization techniques important from basic as well as applied point of view.

PSO5: Due to training in various software/s the students are enabled for proper analysis of the data and preparation of manuscripts / presentation.

Duration: One Semester (Six months)
Total Credit requirement: 14 Credits

Semester 1						
Course Code	Nomenclature of Course	Theory Marks(end semester Examination	Internal Assessment marks	Maximum marks	Hours/ Week	Credits
20PHYPC1 (Compulsory for all Ph.D. Course work)	Research Methodology	80	20	100	4	4
20PHYPC2 (Compulsory for all Ph.D. Course work)	Research and Publication Ethics	40	10	50	2	2
20PHYPC3	Electronic Properties of Materials	80	20	100	4	4
20PHYPC4	Characterization Techniques	80	20	100	4	4
Total marks/Credits				**350**		**14**

Note:

i. **The compulsory course on 'Research and Publication Ethics' shall be offered by Ch. Ranbir Singh Institute of Social and Economic Change for all UTDs/Centers/Institutes passed vide Resolution No. 27 of the 271st meeting of EC held on 29.7.2020. (As per template provided by Director, IQAC)**

Name of the Program	Ph.D. course work	Program Code	PHYPH
Name of the Course	Research Methodology	**Course Code**	20PHYPC1
Hours/Week	4	**Credits**	4
Max. Marks.	80	**Time**	3 Hours

Note: The examiner has to set a total of nine questions (two from each unit and one compulsory question consisting of short answer from all units. The candidate has to attempt one question each from each unit along the compulsory question (5 x 16 = 80 marks)

Course Objectives:

1. To apprise the students regarding selection of research problem and its objectives
2. To acquaint the students with various aspects of preparation of research proposal and writing of research articles
3. To enable the students in data handling, analysis, presentation and selection of suitable journal for publication.
4. To handle applications of MS office such as MS word, Power Point, Equation editor etc.
5. To master MATLAB software for solutions of differential equations and plotting of graph.

Course Outcomes:

1. The research students were enabled to appreciate the complexities of research proposals and implications.
2. The students got well versed with skills of writing research papers and conclusion of the research problem
3. Exposure to MS Office and other scientific softwares enabled the scholars in analyzing the data as well as in preparing manuscript and presentation
4. Students got familiarized with MATLAB software and find themselves confident in solving differential equations pertaining to different physical systems
5. Students acquired the skills of plotting multi-functional graph

Unit - I

Introduction of research methodology: meaning of research, objectives of research, types of research, significance of research, research and scientific method, research process; research problem: definition, necessity and techniques of defining research problem, formulation of research problem, objectives of research problem.

Unit - II

Scientific communications: publishing research papers, selection of a journal, writing of research papers: abstract, introduction/ formulation of problem, experimental details, results &discussion, references, submission of manuscript and handling of reviewer's comment; writing of thesis: format of a thesis, review of literature, writing methods, preparation of tables and figures, writing discussion; conclusions, summary and synopsis, research ethics: copyright, plagiarism.

Unit - III

Presentation: poster and oral, presentation tools, introduction to presentation tool, MS power point features and functions, creating presentation, customizing presentation, presentation, reference citing and listing bibliography, computer applications in research: introduction to origin software; MS office, word basics. Mail merge, macros, math type, equation editor; MS excel: excel basics, data sort, functions; measurements and uncertainty, error analysis; web search internet basics, internal protocols, pre-requisites, search engines, searching hints.

Unit - IV

MATLAB: Introduction, working with arrays, creating and printing plots, Interacting computations: matrices and vectors, matrices and array operations, built in functions, saving and loading data, plotting simple graphs programming in MATLAB: script files, function files, Compiled files, p-code, variables, loops, branches, and control flow, input/ output, advanced data objects, structures, cells, solution of ordinary differential equation; first order linear ODE, second order nonlinear ODE, tolerance, ODE suite

References:

1. Pratap, R. (2010). Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers. Oxford University Press.
2. Palm III, W.J. (2007). A Concise Introduction to Matlab. McGraw Hill.
3. Gurumani, N. (2010). Scientific Thesis Writing and Paper Presentation. MJP Publishers.
4. Kothari, C.R. (2004). Research Methodology: Methods and Techniques. New Age International.
5. Wheatley, P. O., & Gerald, C. F. (2002). Applied Numerical Analysis. Addison Wesley.
6. Schwartz H.R., Stiefel E &Rustishausar. (1976). Numerical analysis of symmetric matrices. Prentice Hall.

Name of the Program	**Ph.D. course work**	**Program Code**	PHYPH
Name of the Course	Research and Publication Ethics	**Course Code**	20PHYPC2
Hours/Week	2	**Credits**	2
Max. Marks.	40	**Time**	3 Hours

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Name of the Program	Ph.D. course work	Program Code	PHYPH
Name of the Course	Electronic Properties of Materials	**Course Code**	20PHYPC3
Hours/Week	4	**Credits**	4
Max. Marks.	80	**Time**	3 Hours

Note: The examiner has to set a total of nine questions (two from each unit and one compulsory question consisting of short answer from all units. The candidate has to attempt one question each from each unit along the compulsory question (5 x 16 = 80 marks)

Course Objectives:

1. To develop understanding about magnetic materials and related applications
2. To develop in-depth understanding of optical materials and related applications
3. To impart detailed knowledge of dielectric and ferroelectric properties of materials
4. To learn theoretical aspects of dielectric and optical properties of materials
5. Application of Quantum mechanics in understanding electronic properties.

Course Outcomes:

1. Capabilityof understanding the magnetic materials.
2. Understanding of various concepts of optical materials.
3. Application of electron theory of solids
4. Appreciation of dielectric properties of materials
5. Ability to realize possible applications of magnetic materials

Unit - I

Drude model: basic assumptions, collision or relaxation times, Hall-effect and magneto-resistance, electrical conductivity, dielectric function and plasma resonance, Sommerfeld model: density of allowed wave vectors, thermal properties of a free electron gas, theory of conduction, Wiedemann–Franz law , effect of periodic lattice potential: Bloch's theorem, crystal momentum, band index and velocity, density of levels and van Hove singularities.

Unit - II

Magnetic behavior: ferromagnetism and anti-ferromagnetism, exchange interaction and magnetic domains, anisotropy energy, transition between domains, solitons, origin of domains, coercivity and hysteresis, ferrimagnetic order, ferrites and garnets, hard and soft magnets, single domain magnets, geomagnetism and bio-magnetism, magnetic force microscopy, spin waves, surface magnetism.

Unit - III

Dielectric constants of solids and liquids, dipole theory of ferroelectricity, thermodynamics of ferroelectric transitions, ferroelectric domains, Clausius-Mossotti relation, dielectric dispersion and losses, classification of ferroelectric materials, piezo-, Ferro- and pyro- electricity, electrostriction

Unit - IV

Optical constants: index of refraction, reflectivity, transmittance, damping constant, penetration depth and absorbance, atomistic theory of optical properties, free electrons with and without damping, bound electrons, Hagen-Rubens relation, quantum mechanical treatment, band transitions, dispersion, plasma oscillations

References:

1. Kasap, S.O. (2017). Principles of Electronic Materials and Devices. McGraw Hill.
2. Hummel, R.E. (2011). Electronic Properties of Materials. Springer.
3. Ashcroft, N. W., &Mermin, N.D. (2003). Solid State Physics. CENGAGE Learning.
4. Kittel, C. (2019). Introduction to Solid State Physics. Wiley India Edition.
5. Dekker, A.J. (2008). Solid State Physics. Macmillan.
6. Solymar, L., Walsh, D., &Syms, R.R.A. (2018). Electrical Properties of Materials. Oxford University Press.

Name of the Program	Ph.D. course work	Program Code	PHYPH
Name of the Course	Characterization Techniques	**Course Code**	20PHYPC4
Hours/Week	4	**Credits**	4
Max. Marks.	80	**Time**	3 Hours

Note: The examiner has to set a total of nine questions (two from each unit and one compulsory question consisting of short answer from all units. The candidate has to attempt one question each from each unit along the compulsory question (5 x 16 = 80 marks)

Course Objectives:

1. To give a detailed flavor of various spectroscopic techniques and their use in material characterization
2. To impart working knowledge of different techniques for electrical and magnetic properties.
3. To enable students, understand the crystal structure determination using x-ray diffraction and transmission electron microscopy.
4. Familiarize the students with probe microscopic techniques such as AFM and STM
5. Train the students regarding use of various equipments of material characterization and data analysis.

Course Outcomes:

1. Exposure to spectroscopic techniques enabled the scholars understand the complexities in Materials Science.
2. Enabled handling of VSM, Hysteresis loop tracer, impedance analyzer.
3. Students empowered in classification of material in crystalline and amorphous forms.
4. Students understood applications of Characterization techniques / setups including DSC, AFM, STM etc. in basic as well as applied research.
5. Enabled the students in data recording, handling and analysis

Unit - I

Basic principle and instrumentation of UV-Vis. spectroscopy, photoluminescence spectroscopy, and ellipsometry, determination of optical band gap and other optical parameters, basic principle of FTIR and Raman spectroscopy, brief idea of set up (includes source, detector, operating conditions and excitation wavelength choice), deconvolution of the peaks, analysis of the spectra based on peak position, FWHM of the vibrational modes. (case study of each technique

Unit - II

Review of magnetic materials, basic principle and brief idea about set-up of vibrating sample magnetometer (VSM) and SQUID magnetometer, magnetization vs. temperature profiling for zero field cooling (ZFC) and field cooling (FC), M-H hysteresis loops, AC magnetic susceptibility, electrical characterization: two probe, four-probe and van-der pauw method for resistivity measurements, Hall effect experiment, dielectric characterization using impedance analyzer, electrochemical techniques: cyclic voltammetry(case study of each technique)

Unit - III

Brief review of crystal structure, X-ray diffraction methods, modern X-ray diffractometer, indexing of X-ray diffraction peaks, data analysis and interpretation, crystallite size and strain measurement in nanomaterials, basic principle of scanning electron microscopy, energy dispersive X-ray analysis, basic principle of transmission electron microscopy, brief idea of set up, sample preparation, imaging modes: bright field imaging, dark field imaging, selected area electron diffraction etc. (case study of each technique)

Unit - IV

Basic principle of atomic force microscopy, brief idea of set up, different modes of AFM (contact &tapping mode) and their importance, basic principle of scanning tunneling microscopy, brief idea of set up/components, different modes of STM and its importance, TGA and DSC/DTA: principle, practical aspects, experimental variables, data analysis and interpretation(case study of each technique)

References:

1. Evans, C., Brundle, R., & Wilson. S. (1992). Encyclopedia of Materials Characterization: Surfaces, Interfaces, Thin Films. Butterworth-Heinemann.
2. Leng, Y. (2013). Materials Characterization: Introduction to Microscopic and Spectroscopic Methods. Wiley-VCH.
3. Hummel, R.E. (2011). Electronic Properties of Materials. Springer.
4. Goldstein, J., Newbury, D.E., Joy, D.C., Lyman, C.E., Echlin, P., Lifshin, E., Sawyer, L., Michael, J.R. (2003). Scanning Electron Microscopy and X-Ray Microanalysis. Springer.
5. Cullity, B.D., & Stock, S.R. (2013). Elements of X-Ray Diffraction. Pearson.

6. Kaufmann, E.N. (2003). Characterization of Materials (Vol 1 & 2). John Wiley and Sons.
7. Carter, C.B., & Williams, D.B. (2016).Transmission Electron Microscopy Diffraction, Imaging, and Spectrometry (Carter, Barry, Williams, David B. Eds.)