Department of Applied Physics, Gautam Buddha University

Course Structure and Syllabus of Ph.D. Physics

(Effective from Session 2023-24)

About the Programme:

Ph.D. Applied Physics is Doctorate programme of the Department of Applied Physics which provides the students a comprehensive insight about the ongoing research in some theoretical and experimental areas.

Programme objectives:

- The objective of Ph.D. Applied Physics program is to provide an education within experimental and theoretical physics and to give the research scholar a broad professional background in physics.
- The research scholars can focus towards theoretical or experimental topics of research based on ongoing research activities at the Department of Applied Physics.
- Through this study, the research scholars acquire and demonstrate advanced knowledge in foundational areas of physics with mastery of their selected subfield.
- To encourage and train the research scholars author or co-author publications in refereed journals, make presentations at national or international meetings (poster/oral talks).

S. No.	Subject Code	Courses	L-T-P	Credits
1.	**AS 601**	Research Methodology	4-0-0	4
2.	**PH 601**	Synthesis and Advanced Characterization Techniques of Materials	3-0-0	3
3.	**PH 603**	Numerical Computing Methods in Research	3-0-0	3
4.	**PH 605**	Seminar		2
5.	**RPE601**	Research and Publication Ethics	2-0-0	
		Total	12-0-0	14

Note:

1. A full time research scholar will complete 14-credits during the course work.

2. A part-time research scholar (working professional) will complete 11-credits during the course work.

3. AH601 (Research methodology), PH605 (Seminar) and RPE601 **(**Research and Publication Ethics) are compulsory for both full-time and part-time students.

AS 601: RESEARCH METHODOLOGY

Credit: 4 (4-0-0)

Basics of Research: Research: Definition, Objectives, Types and Characteristics; Hypothesis: Meaning and types; Research methods vs Methodology. Positivism and post- positivistic approaches to research

Research Formulation: Research Formulation – Defining and formulating the research problem; Characteristics of a good research problem; Selecting the problem; Literature review: Primary and secondary sources; Research proposal or synopsis Web as a literature source, searching the web; Organizing the literature and identifying gap areas from literature review.

Research Design and Methods: Research design: Basic principles, Need of research design, Features of a good research design; Important concepts relating to research design; Observations and Facts; Laws and Theories, Prediction and explanation, Induction, Deduction, Development of Models; Developing a research plan-Exploration, Description, Diagnosis, Experimentation. Determining experimental and sample designs.

Data Collection and Analysis: Observations and collection of data; Sample and sampling methods; Data processing and analysis, Statistical packages of data analysis; Hypothesis testing, Generalization and interpretation; Role of ICT in researchs.

Research Report: Types of report-Technical reports and thesis; Structure and components of a scientific report, Steps in report preparation: Layout, structure and language of typical reports, illustrations and tables; Bibliographic entries, referencing and footnotes; Oral presentation: Planning and practice, use of visible aids, Importance of effective communication

Commercialization of knowledge and technologies and academic ethics; Intellectual property rights; Plagiarisms paraphrasing and copywrite violation, consequences of plagiarism; Reproducibility and accountability; Citation counting and impact factor, Scientific citation index (SCI), Scientific citation index-expanded (SCI-E), H-index

References

1. Anthony, M., Graziano, A.M. and Raulin, M.L., 2009. Research Methods: A Process of Inquiry, Allyn and Bacon.
2. Fisher R. A., Statistical Methods for Research Workers, Cosmo Publications, New Delhi
3. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
4. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International, New Delhi 418p.
5. Montogomery D.C. 2001, Design and Analysis of Experiments by John Wiley
6. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes
7. Trochim, W.M.K., 2005. Research Methods: The Concise Knowledge Base, Atomic Dog Publishing. 270p.
8. Wadehra, B.L. 2000. Law Relating to Patents, Trade-marks, Copyright, Designs and Geographical indications. Universal Law Publishing, New Delhi

PH601-SYNTHESIS AND ADVANCED CHARACTERIZATION TECHNIQUES OF MATERIALS
Credits: 3 (3-0-0)

Course objectives:

- In this course, the Ph.D. students learn about the various techniques of synthesis of the materials with key experimental details.
- Furthermore, various important basic and advanced characterization techniques are also taught in this course.
- The objective of the course is to make the students aware about the experimental techniques and error analysis in the experimental observations, so that they can apply these concepts during their research work.

Synthesis techniques: Top down and bottom-up techniques, sol gel techniques, spin coating, electrodeposition, introduction to lithographic techniques, Introductory non-lithographic techniques: thermal and e-beam evaporation, sputtering (dc, rf and magnetron), chemical vapour deposition, pulsed laser deposition, molecular beam epitaxy.
Advanced characterization techniques: Structural investigation methods: Diffraction from crystalline materials, powder diffraction method, X-ray and electron sources, Transmission electron microscopy (TEM), Scanning transmission electron microscopy (STEM), Surface probing techniques: Scanning electron microscopy (SEM), Energy dispersive X-ray analysis (EDAX), Atomic force microscopy (AFM), Scanning tunnelling microscopy (STM), Spectroscopic techniques: X-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy (AES), Fourier transform infrared (FTIR) spectroscopy, Ellipsometry, Optical spectroscopy: UV-Vis spectroscopy, photoluminescence (PL) spectroscopy, Thermal properties measurement: Differential thermal analysis (DTA), Thermogravimetric analysis (TGA), Transport Properties Measurement: Vander Pauw method, Hall measurements at low and high temperatures.
Error Measurements: Units and standards, Errors in measurement: definitions, accuracy, precision, resolution, composition of measuring system, selection factors, types of measurement error: gross, systematic, random, and limiting errors.

Texts/References

1. Handbook of Nanostructured Materials and Nanotechnology: H.S. Nalva (editor)
2. Nano Technology/ Principles and Practices: S.K. Kulkarni
3. Characterization of Nanomaterials, Editors-in-Chief: Sneha Mohan Bhagyaraj, A volume in Micro and Nano Technologies (2018)
4. B. D. Cullity, S.R. Stock, “Elements of X-Ray Diffraction”, Prentice Hall (2001).
5. P. J Goodhew, J. Humphreys, R. Beanland, “Electron Microscopy and Analysis”, Taylor & Francis (2000)
6. J. M. Hollas, “Modern Spectroscopy” John Wiley & Sons Ltd. (2004)
7. R. P. Prasankumar (Editor), A. J. Taylor (Editor), “Optical Techniques for Solid-State Materials Characterization”, CRC Press (2011).
8. Kai-Erik Peiponen**,** Risto Myllylä**,** Alexander V. Priezzhev, “Optical Measurements Techniques,” Springer (2009)
9. J. P. Bentley, **“**Principles of measurement systems”, Prentice Hall (2005).

PH 603-NUMERICAL COMPUTING METHODS IN RESEARCH
Credits: 3 (3-0-0)

Course objectives:

- The objective of the course is to introduce the Ph.D. students to computer programming through MATLAB.
- In addition, the course will teach the students numerical methods for solving algebraic and differential equations. The course has been designed to enhance the problem-solving skill of prospective students.

Root finding techniques: Fixed point iteration, Bisection, Newton-Raphson and secant methods, Interpolation and extrapolations: Newton Forward differences and Lagrange's polynomials, Curve fitting, System of linear equations - direct and iterative methods, Eigenvalues and Eigenvectors; Numerical Differentiation: Divided and finite difference methods, Numerical Integration: Trapezoidal and Simpson's 1/3, 3/8 rules, Gaussian quadrature, Ordinary differential equations: Euler's Method, Crank–Nicolson's method, Runge-Kutta methods, Shooting method; Partial Differential Equations: Elliptic, Parabolic and Hyperbolic, Case study for physical systems.
Introduction to MATLAB Programming: Scripts and Functions, Loops and Conditional statements; Matrix operations in MATLAB, User defined functions, File input & output, 2D and 3D plotting, Fast Fourier Transform using MATLAB. Application of Matlab in physics related problems.

Texts/References

1. Rudra Pratap, "Getting started with Matlab 7: A quick introduction for Scientists and Engineers", Oxford University Press (2002)
2. W. Y. Yang, W. Cao, T. Chung and J. Morris, "Applied Numerical Methods using MATLAB," Wiley Interscience (2005).
3. M. K. Jain, S. R. K. Iyenger and R. K. Jain, "Numerical Methods for Scientific and Engineering Computation", New age international publishers (2003).
4. S.R. Otto and J.P. Denier, "An Introduction to Programming and Numerical Methods in MATLAB", Springer-Verlag (2005).