Ph. D. Physics Course Work Syllabus

BODOLAND UNIVERSITY

(Effective from Academic Year 2021-22)

Department of Physics

Bodoland University

Kokrajhar - 783370

Table of Contents

Programme outcome

- Educate and train the research scholars to better prepare for their strategic approach for Ph. D. research problem.
- Inspire the scholars to demonstrate and maintain highest standard in good research practices throughout their research career.
- Train the scholars on the learning scopes/tools from various sources appropriate for upgrading their skills and proper utilization.
- Introducing the scholars with up to date techniques and tools used in physical sciences research.
- To develop effective scientific and technical communication skills
- To provide a strong foundation in ethics related issues in research work (publications, patent, copyrights, plagiarism etc.) during their Ph. D. work and beyond.

Ph. D. Course work Programme Structure

Paper Code	Name of the Paper	Credits (L+T+P)	Mark Distribution	Marks
PHDPHY01	Research Methodology	2+1+0 = 3	20+20+60	100
PHDPHY02	Computational Physics	2+1+0 = 3	20+20+60	100
PHDPHY03	General Physics	2+1+0 = 3	20+20+60	100
PHDPHY04A	Physics of Nanomaterials	2+1+0 = 3	20+20+60	100
PHDPHY04B	Relativistic Heavy Ion Physics	2+1+0 = 3	20+20+60	100
PHDPHY05	Research and Publication Ethics	2+0+0 = 2	50	50
Total		**14**		**450**

N.B. A candidate has to choose either PHDPHY04A or PHDPHY04B depending on candidate's area of Research

Paper - I

PHDPHY01: Research Methodology

Total Credit: 3 (2+1+0)

Course Learning Outcomes: After completing this paper, the students will be able to: (i) identify research problems in various fields, (ii) review existing literature in the area of interest, (iii) identify a research problem and to approach investigations scientifically in order to find solutions for research problems of interest, (iv) selecting a suitable methodology for data collection and analyzing data, (v) enhance abilities of data analysis and interpretation, (vi) build acumen for preparation of effective report and presentation , (vii) prepare research report.

Unit I: Research methodology: An introduction

Research concept, identification of research problem, Meaning of Research, Objectives of Research Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Research Process, Criteria of Good Research.

Unit II: Research Design

Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs

Unit III: Scientific writing

Forms of scientific writing i.e. research articles, notes, report, review, monograph, dissertation/thesis, popular article etc. components of research article, writing strategy for a research article.

Unit IV: Intellectual property right

Introduction to IPR, Patent laws, process of patenting a research finding, copyright, cyber laws.

***Reference books*:**

1. Kothari, CR. *Research Methodology Methods and Techniques* (New Age International Publishers, New Delhi, 2009).

2. Ackoff, Russell L. *The Design of Social Research* (Chicago Press, 1961).

3. Ackoff, Russell L. *Scientific Method* (New work: John Wiley & Sons,1962).

Paper – II
PHDPHY02: Computational Physics
Total Credit: 3 (2+1+0)

Course Learning Outcomes: After learning this course, the learners will be able to: (i) write article, report, letter, book, thesis, and beamer presentation using LaTex, (ii) perform matrix operations such as inversion, diagonalization, eigenvectors and eigenvalues using numerical method, (iii) perform polynomial interpolation such as Newton-Gregory and Lagrange interpolation method etc., (iv) compute numerical integration using trapezoidal rule, Simpson's 1/3 rule, and Monte Carlo method, (v) solve first and second order linear differential equation using Euler method, Runge-kutta method and Numerov method, (vi) simulate random processes such as: coin tossing or dice throwing game, simulation of nuclear decay etc.

Unit I : Basic of Computer Application

Operating system, System Software, Application Software, Use of Microsoft office word in word processing, graphical presentation and preparation of documents, Power Point in graphical presentation and preparation of documents, Creating and printing a presentation, producing a slide show, Excel in data analysis, Editing and formatting worksheets, performing basic calculations, working with charts, Browsing internet for related literature and Inter Groups for sharing of data and result.

Unit II: Typesetting with Latex

Understanding LaTeX compilation: Basic Syntax, Writing equations, Matrix, Tables. LaTeX editor: Texmaker; configuration, feature and use. Classes: Introduction to basic classes like article, book, report. Applications: Writing Resume, articles/research papers, Presentation using beamer, Writing Thesis using LaTeX.

Unit III: Numerical Techniques (C++ / Python / SciLab)

Sorting, interpolation, numerical integration, linear algebra and matrix manipulations, inversion, diagonalization, eigenvectors and eigenvalues, Solution of differential equation (1st & 2nd order) : Euler, Runge-Kutta methods, Numerov method.

Unit IV: Simulation Techniques (C++ / Python / SciLab)

Simulation of Random variables, discrete and continuous. Calculation of integrals, Monte Carlo evaluation of pi. Simulation of simple processes: coin tossing or dice throwing game, simulation of nuclear decay.

***Reference books*:**

1. Introductory Methods of Numerical Analysis – *S. S. Sastry (*PHIL *Pvt. Ltd.)*
2. Numerical methods for Scientific and Engineering Computation: M. K. Jain, S. R. K. Iyengar and R.K. Jain. (Wiley Eastern Limited),
3. Programming with C++ – *Ravichandran (McGraw Hill Ed.)*
4. Schaum's Outline of Programming with C++ – *John Hubbard (McGraw Hill Ed.)*
5. Numerical Recipes: W.Press *et.al.*, (Cambridge University Press).
6. Data reduction and error analysis for the Physical Sciences, 3e, Philip R Bevington & D. KeithRobinson .McGraw Hill (2003).
7. Peter Norton "Introduction to Computers", 6th International Edition (McGraw Hill)

Paper - III
PHDPHY03: General Physics
Total Credit: 3 (2+1+0)

Course Learning Outcomes: After completing this course, scholars will be able to comprehend the: (i) Construction of characteristic polynomial of a matrix and their use in identifying eigenvalues, Laplace transform and Fourier-transform in solving initial-value problems for linear differential equations with constant coefficients (ii) Approximate methods for solving the Schrödinger equation in connection with various quantum mechanical problems (iii) Basic principles of spectroscopy, rotational and vibrational spectra, idea about extracting the structure of an atoms and molecules from the interpretation of its IR and Fourier transform infrared (FT-IR) spectra

---

Unit I: Mathematical Physics
Matrix: Eigenvalues and eigenvectors; Applications of Laplace & Fourier transform.

Unit II: Quantum Mechanics:
Time-independent perturbation theory, Variational Principle, WBK approximation, Scattering theory.

Unit III: Element of Spectroscopy
Designation of Atomic and Molecular States, Electronic, vibrational and rotational spectra, concept of allowed and forbidden, Transitions, Fourier transform (FT) spectroscopy & FT-IR – Enhancement of spectra, Fundamental laws of photometry – spectroscopic accuracy – photometric precision – Quantitative methodology – Difference spectroscopy – derivative spectroscopy

***Reference books*:**

1. Mathematical Methods for Physicists – *G.B. Arfken*
2. Mathematical Physics – *H.K Dass*
3. Quantum mechanics – *A. Ghatak and S. Lokanathan*
4. Introduction to Quantum Mechanics – *David J Griffiths*
5. Quantum Mechanics – *N. Zettili*
6. Principles of Quantum Mechanics – *R. Shankar (3rd Ed. Springer)*
7. Molecular Structure and Spectroscopy - G Aruldhas, Prentice Hall of India
8. Instrumental Methods of Analysis - HH Willard, LL Merritt, JA Deann, FA Settle, CBS Publishers & Distributors

Paper - IV(A)
PHDPHY04A: Physics of Nanomaterials
Total Credit: 3 (2+1+0)

Course Learning Outcomes: This course is designed to introduce nanoscale science and nanotechnology to the learners in building in depth knowledge for taking up nanotechnology as a career. Topics that will be discussed include nanomaterials synthesis, their unique properties and their broad applications. On completion of the course the student will be able to (i) synthesize different structured nanomaterials using various synthesis methods (ii) characterize and analyze materials for important properties using various tools (iii) explain the potential application of nanomaterials in various fields.

Unit I: Introduction to nanophysics

An overview of quantum mechanical concepts related to low dimensional systems, de Broglie wavelength, Quantum confinement: Quantum well, quantum wire, and quantum dot, strong and weak confinement.

Unit II: Thin solid films

Thin Films, different methods of thin film preparation: chemical and physical route, condensation, nucleation and growth, defects, size effect on transport properties, thin film semiconducting devices, magnetic thin films.

Unit III: Nanostructures and heterojunctions

Introduction to nanostructured materials: metal-oxide nanoparticles, nanorods and nanotubes; core-shell nanostructures: inorganic-inorganic, inorganic-organic, organic-organic and polymer-inorganic core shell structures, Heterojunctions, Type I and Type II heterojunctions

Unit IV: Experimental Techniques

Production and measurements of Low pressure: Rotary pump, Turbo molecular pump, oil diffusion pump, Gauges: Pirani, Penning, leak detection; principle and applications of powder X-ray diffraction spectroscopy, spectrometer (IR and UV–visible), Scanning electron microscope (SEM), Transmission electron microscope (TEM), Atomic force microscope (AFM).

***Reference books*:**

1. Introduction to Solid State Physics – *C. Kittel.*
2. Solid State Physics – *A.J. Dekker.*
3. Introductory Solid State Physics – *H.P. Myers.*
4. Solid State Physics – *N.W. Ashcroft and N.D. Mermin.*
5. Magnetism in solids – *D. H. Martin*
6. Physics of Magnetism – *S. Chikazumi*
7. Vacuum Technology, A. Roth, (North Holland, Elsevier Science B.V. 1990)
8. Hand Book of Thin Film Technology, Maissel and Glange.
9. Handbook of Vacuum Science and Technology; Hoffman, Singh and Thomas; Academic Press, 1998

Paper - IV(B)
PHDPHY04B: Relativistic Heavy Ion Physics
Total Credit: 3 (2+1+0)

Course Learning Outcomes: After successful competition of the course, the learner will be able to (i) apply conservation laws to predict different interaction processes (ii) calculate various internal quantum numbers for elementary particles (iii) apply the relativistic kinematics to solve scattering and decay problems (iv) get the basic knowledge of heavy-ion physics and learn the indirect signatures of Quark-Gluon Plasma (v) simulate events with various Monte Carlo event generators in computer (vi) get the basic idea of detector simulation and data analysis.

Unit - I: Elementary particle physics
Conservation laws, Gell-Mann--Nishijima scheme**,** Quark Model, Properties of quarks and their classification, Color degree of freedom, Gell-Mann – Okubo mass relation, Introduction to Standard Model, Fundamentals of Quantum Chromodynamics

Unit - II: Relativistic Kinematics
Lorentz transformation; Mandelstam variables, Detailed derivation of kinematic variables and their transformations. Collision & Decay kinematics. Rapidity, pseudo-rapidity.

Unit - III: Introduction to relativistic heavy-ion collisions
Phase transition in strongly Interacting Matter-QGP, Nuclear stopping power and nuclear transparency, Space-time picture of collisions, Time history of ultra-relativistic AA collisions, Geometry of heavy ion collisions.

Unit - IV : Observables & QGP signatures
Global Observables: Multiplicity, (pseudo)rapidity distributions, invariant yields; Centrality of events: Glauber Model, experimental methods. Quarkonia suppression, Collective Flow, jet quenching.

Unit - V: Event Generators
Introduction to monte carlo (MC) event generators: HIJING, PYTHIA, UrQMD, AMPT.

Unit - VI: Introduction to data analysis
Luminosity, Event rate, hits, primary vertex, tracks, secondary vertex, trigger and pileup.

Concept of detector and electronic noise, Detector calibration, Acceptance and Efficiency estimation, event and physics trigger selection, analysis for physics objectives. Particle identification in high energy experiments: dE/dx, Range, TOF technique, Transition radiation.

Unit - VII: Experimental Results and Future Programmes:

Past & future heavy-ion experiments.

Reference books:

1. The Physics of the Quark-Gluon Plasma - S. Sarkar, H. Satz, B. Sinha (Springer)
2. Relativistic Kinematics; a guide to the kinematic problems of High Energy Physics by R. Hagedorn
3. Introduction to high energy Heavy-Ion Collisions - C. Y. Wong
4. Quark Gluon plasma from Big Bang to Little Bang - K. Yagi, T. Hatsuda and Y. Miake
5. Phenomenology of Ultra-Relativistic Heavy-Ion Collisions - Wojciech Florkowski
6. A Short Course on Relativistic Heavy Ion Collisions - Asis Kumar Chaudhuri
7. Ultrarelativistic Heavy-Ion Collisions - Ramona Vogt
8. TheExperimental Foundations of particle physics - R.N.Cahn and G.Goldhaber
9. Techniques For Nuclear And Particle Physics Experiments : How to approach - W. R. Leo (Springer)
10. Experimental Techniques in High Energy Nuclear and Particle physics - T. Ferbel (WorldScientific)
11. Introduction to Experimental particle physics - R. C.Fernow
12. Data Reduction and Error analysis for the physical sciences - P. Bevington and D.K. Robinson
13. Data analysis Techniques for High Energy physics - R. Frunwirth, M. Regler, R. K. Bock and H. Grote

Paper - V
PHDPHY05: Research and Publication Ethics
Total Credit: 2 (2+0+0)

Course Learning Outcomes: This course is primarily designed for Ph. D students focusing philosophy of science and ethics. On completion of this course student will be able to: (i) describe and apply theories and methods in ethics and research ethics (ii) acquire an overview of important issues in research ethics, like responsibility for research, and scientific misconduct (iii) acquire skills of presenting arguments and results of ethical inquiries.

THEORY:

Unit - I: Philosophy and Ethics
Introduction to philosophy: definition, nature and scope, concept, branches, Ethics: definition, moral philosophy, nature of moral judgements and reactions.

Unit - II: Scientific Conduct
Ethics with respect to science and research, Intellectual honesty and research integrity, Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP), Redundant publications: duplicate and overlapping publications, salami slicing, Selective reporting and misrepresentation of data.

Unit - III: Publication Ethics
Publication ethics: definition, introduction and importance, Best practices / standards setting initiatives and guidelines: COPE, WAME, etc., Conflicts of interest, Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types, Violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, Predatory publishers and journals.

PRACTICE:

Unit-IV: Open Access Publishing

I. Open access publications and initiatives
II. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies
III. Software tool to identify predatory publications developed by SPPU
IV. Journal finder/ journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

Unit - V: Publication Misconduct

A. Group Discussions

I. Subject specific ethical issues, FFP, authorship.
II. Conflicts of interest.
III. Complaints and appeals: examples and fraud from India and abroad

B. Software tools

Use of plagiarism software like Turnitin, Urkund and other open source software tools

Unit - VI: Databases and Research Metrics

A. Databases

I. Indexing databases
II. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics

I. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
II. Metrics: h-index, g index, ilO index, altmetrics

***References*:**

1. Bird, A. (2006). *Philosophy of Science.* Routledge.
2. MacIntyre, Alasdair (1967) *A Short History of Ethics.* London.
3. P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN: 978- 9387480865

4. National Academy of Sciences, National Academy of Engineering and Institute of Medicine. (2009). *On Being a Scientist: A Guide to Responsible Conduct in Research: Third Edition*. National Academies Press.
5. Resnik, D. B. (2011). What is ethics in research & why is it important. *National Institute of Environmental Health Sciences,* 1-10. Retrieved from https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfrn
Beall, J. (2012). Predatory publishers are corrupting open access. Nature, 489 (7415), 179-179. https://doi.org/10.1038/489179a
6. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance (2019) , ISBN: 978-81-939482-1-7
7. http://www.insaindia.res.in/pdf/Ethics Book.pdf
8. Kothari, CR. *Research Methodology Methods and Techniques*. New Age International Publishers, New Delhi, 2009.
9. Ackoff, Russell L. *Scientific Method*, New work: John Wiley & Sons,1962.
10. Pruzan and Pete. Research Methodology: The Aims, Practices and Ethics of Science (The recent articles on specific topics will be announced in the class)

****