# SYLLABUS
# For
# Ph.D. Coursework in
# PHYSICS

(in CBCS format)

(Effective from the academic session 2019-2020 and onwards)

## DEPARTMENT OF PHYSICS
## BANKURA UNIVERSITY
## BANKURA

**Bankura University**
**Department of Physics**
**Ph.D. Coursework Syllabus**

Important points to be noted:

- Duration of the Coursework: One Semester (6 months)
- Total marks: 200 (Two papers 100 marks each)
- Examinations will be held at the end of the semester

Structure:

| Papers | Topics and the way of Evaluation | Marks Distribution (Credits) | Lectures per week |
|---|---|---|---|
| Paper-I Compulsory Units | Group-A<br>Research Methodology | 50 (2) | 2 |
| | Group-B<br>Computer Applications | 50 (2) | 2 |
| Paper-II | Group-A<br>Advance Physics | 50 (2) | 2 |
| | Group-B<br>Term paper/ literature review | 50 (2) | 2 |

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# Paper-I

**Group-A: Research methodology in general**

Meaning of scaling; Scales of measurement. Uncertainties in measurements, single-variable and multivariable function, propagation of errors, Analysis distribution, some statistical ideas, distribution and probabilities, continuous distribution, normal distribution, Gaussian distribution. Confidence limits and error bars. Least square fitting of some complex functions.

Concept of research; Objective and motivation in research; Significance, Types and process of research; Different approaches of research; Salient points of good research; Research methodology in basic science. Writing literature review, effective poster presentation; writing scientific papers, Internet in scientific research. Procedure for obtaining a patent.

**Group-B: Computer applications in physics**

Introduction to Linux and FOSS software. Basic shell commands. Introduction to compiling and linking. Using IDE for coding.

Typesetting with LaTeX: Concept of LaTeX and contrast with word processors: WYSIWYG vs WYSIWYM. LaTeX Document Structure. Text and paragraph formatting, Lists and Tables. Math models. Figure environment and importing graphics. Review of procedural programming in C

Sequential, selection and loop structure; Pointers and arrays; Functions and subprograms; Structures, unions and enumerated types; Data structures and linked lists.

Introduction to procedural programming in python

Basics of the python interpreter. Setting up and using python Modules, functions and lambdas in python. Variables and scoping.

Basic python objects and native datatypes: Basic arithmetic operations and operators. Control flow and decision control.

Lists in python. Errors and exceptions. Scientific computing in python using numpy/scipy, matplotlib.

**References:**


1. C R Kothari, Research Methodology: Methods and Techniques, New Age International (P) Ltd. (2010) , New Delhi
2. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
3. Handbook of Communication and Social Interaction Skills by John O. Greene, Brant Raney Burleson.
4. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
5. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, SAGE Publications
6. Inderpal Singh, Research Methodology and Statistical Methods, Kalyani Publishers, Ludhiana.
7. G Kanji 100 statistical tests, Sage Publications
8. A.S. Gaur & S.S. Gaur, Statistical Methods for Practice and Research (AGuide to Data Analysis using SPSS), Sage Publications
9. C. Boyer, History of Mathematics.

# Paper-II

# Group-A

## Advanced Physics:

### Nuclear Physics:

Concept of atom to nucleus, Measurement of Nuclear size, Nuclear charge and mass distribution, Nuclear shape, Concept of Nuclear Binding Energy, Deuteron problem, Concept of Nuclear Force, Experimental techniques for studying nuclear physics, interaction of nuclear radiation with matter, detector physics, Nuclear reactor.

### Nonlinear Dynamics:

Dynamical System, phase space, fixed points. Nonlinear dynamical systems. Dynamical equations and Stability for linear systems. Flow defined by nonlinear systems of ODEs, linearization and stable manifold theorem. Planar flows: saddle point, nodes, foci, centers and nonhyperbolic critical points. Bifurcation theory: saddle-node, pitch-fork, Hopf, period doubling, homoclinic bifurcations. Applications in: Laser model, population dynamics.

Limit cycle oscillations and Chaos: Concept of limit cycle, Poincare-Bendixon theorem; role of nonlinearity: From harmonic oscillator to Van der Pol oscillator, Chaos, Lorenz equation and Rossler equation. Applications in: Chaos in electronic oscillators, chaos in Laser system.

Discrete time nonlinear systems: logistic map, sine circle map, linear stability analysis; numerical analysis of the logistic map; universality and the Feigenbaum numbers; bifurcation and chaos, intermittency, crises; Applications in: population dynamics, discrete phase-locked loop system, power electronics.

### General Theory of Relativity and Cosmology:

Equivalence principle and a metric for the space-time. Black Holes; FRW models; gravitational lensing.

Qualitative ideas of the large scale structure of the universe. Standard Cosmology, Friedmann metric, Hubble law.

Observational Parameters: deceleration parameter, equation of state parameter, redshift parameter, etc; temporal history for different curvatures, abundance of lighter elements, cosmic microwave radiation, cosmological singularity.

Problem with standard cosmology. Dark energy and Dark matter, observational evidence, models with cosmological constant, dynamical origin of cosmological constant, Inflationary models, structure formation (qualitative), Late time accelerating universe, $\Lambda$CDM model.

### Quantum and Nonlinear Optics:

### Quantum optics

Quantization of electromagnetic field, coherent state, squeezed state, nonclassicality of radiation field, witnesses and measures of nonclassicality.

**Nonlinear Optics**

Introduction, nonlinearities of the polarization, generation of second harmonic, D.C., sum and difference frequency generation, anharmonic oscillator model, Miller's rule, crystal symmetry, coupled amplitude equation, Manley-Rowe relation.

**Second Harmonic Generation**

Basic equation, conversion efficiency and parameters affecting doubling efficiency, various methods of enhancing conversion efficiency, second harmonic generation with Gaussian beam, intra-cavity second harmonic generation.

**Higher Order Nonlinear Processes**

Four wave mixing processes-third harmonic generation, resonance enhancement of nonlinear susceptibilities, different phase matching techniques.

**References:**


1. Introductory Nuclear Physics- K. S .Krane (Wiley India)
2. Nuclear Physics: Theory and Experiment- R. R. Roy and B. P. Nigam (John Wiley and Sons)
3. Techniques for Nuclear and Particle Physics Experiments - William R. Leo (Springer-Verlag Berlin Heidelberg GmbH). DOI 10.1007/978-3-642-57920-2
4. Stephen Wiggins, "Introduction to Applied Nonlinear Dynamical Systems and Chaos", Springer-Verlag, Second Edition
5. Steven Strogatz. "Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering", Levant Publishers, 1994.
6. Edward Ott, Chaos in Dynamical Systems, Cambridge University Press
7. Introduction to Cosmology – J.V.Narlikar (Cambridge University Poress)
8. General Relativity, Astrophysics and Cosmology – A.K.Raychaudhuri, S.Banerji and A.Banerjee (Springer-Verla, 1992)
9. Quantum optics – G. S. Agarwal
10. Quantum optics: An Introduction – Mark S. Fox.


## Group-B

**Term Paper/ literature Review**
**Full marks: 50**

Students are to produce a term paper/ literature Review on some suitable topic selected by Research Guide/Teacher and submit it. The student should create a presentation for this. The student has to present the term paper/ literature Review in front of all teachers as well as external examiner.