SYLLABUS

For

Ph. D. Coursework in

PHYSICS

(Effective from the academic session 2020 – 2021 and onwards)

DEPARTMENT OF PHYSICS

THE UNIVERSITY OF BURDWAN

Ph. D. Course Work in Physics

Course Structure

Course Code	Course name	Credit	Marks
PHDCW 101	**Research Methodology**	**4**	**50**
PHDCW 102	**Research & Publication Ethics**	**2**	**25**
PHDCW 103	**Advanced Physics**	**4**	**50**
PHDCW 104	**Term paper(s) & Seminar Presentation(s)**	**4**	**50 (25+25)**
	Total	**14**	**175**

1 Credit: 1 class per week

Course code: PHDCW 101

Research Methodology

Unit I: 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.

Unit II: Computer applications in scientific research

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.

Unit III: Some Pedagogical aspects of Physics

Mathematical Methods: Integral transforms with applications. z-transform and its applications.

Landau theory of phase transition. Continuous and first order phase transition with examples. Order parameter and critical exponent. The concept of fluctuations in statistical physics.

Some exactly solvable problems in Quantum Mechanics: Harmonic oscillator, Hydrogen Atom. Rotation and Angular Momentum, Rotation of spin states. Scattering – Born Approximation, Partial Wave Analysis, Scattering of Identical Particles. Interaction of atoms with Radiation.

One-electron atom – Characteristics, Fine structure and hyperfine structure. Many Electron Atoms – Characteristics and Approximations; Introduction to Molecular Orbitals. Determination of Molecular Structure – Experimental procedures and theoretical methods.

Course code: PHDCW 102

Research & Publication Ethics

- **PHILOSOPHY OF ETHICS**

1. Introduction of philosophy: Definition, Nature and scope, concept, branches
2. Ethics: Definition, moral philosophy, nature of moral judgements and reactions

- **SCIENTIFIC CONDUCT**

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification an, Fabrication, and Plagiarism (FFP)
4. Redundant publications: Duplicate and overlapping publications, Salami Slicing
5. Selective reporting and mis-presentation of data

- **PUBLICATION ETHICS**

1. Publication ethics: Definition, introduction and importance
2. Best practices/standards setting initiatives and guidelines: COPE, WAME, etc.
3. Conflicts of interest
4. Publication misconduct: Definition, concept, problems that lead to unethical behavior and vice-versa, types
5. Violation of publication ethics, authorship and contributor ship.
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

- **OPEN ACCESS PUBLISHING**

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-achieving policies
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder/journal suggestion tool viz., ZAME, Elsevier journal Finder, Springer journal suggester, etc.

- **PUBLICATION MISCONDUCT**

A. Group discussion

1. Subject specific ethical issues, FFP, authorship

2. Conflicts of interest
3. 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

DATABASES AND RESEARCH METRICS

A. Databases

1. Indexing databases
2. Citation databases: Web of science, Scopus, etc.

B. research Metrics

1. Impact Factor of journal as per journal Citation report, SNIP, SJR, IPP, Cite Score
2. Metrics: h-index, g index, i10 index, altmetrics.

Course code: PHDCW 103

Advanced Physics

Unit I

Basic properties of linear vector space, angular momentum in quantum mechanics, angular momentum eigenstates and their addition in Hilbert space, Wigner Eckert theorem and its applications. Relativistic wave equations: the Klein-Gordon and the Dirac equations and related physics. Basic aspects of quantization of fundamental fields. Second quantization as applied to non-relativistic many-body systems.

Unit II

Bloch electrons and band structure, Band electrons in a magnetic field. Thermodynamic functions of a vibrating solid in the harmonic approximation, an-harmonic interaction. Boltzmann transport equation, Electron-phonon interaction, Kubo formula for electrical conductivity. Hatree-Fock approximations for the electron gas, Plasma Oscillations. Spin Hamiltonian. Heisenberg Model, Indirect Exchange and Superexchange, Spin waves and magnons, Spin waves in Antiferromagnets. Ginzburg-Landau theory of Superconductivity, Functional masterials, GMR, CMR.

Unit III

Brief discussion on crystal symmetries, Point groups and space groups. Structure factor determination of some crystal systems. Electron diffraction. Neutron diffraction.

Unit IV

Cosmology: Some aspects of FRW Universe, Red shift, Velocity – distance relation and Hubble's law, Luminosity distance, Problems of standard cosmology, Early Universe: Inflationary paradigm, Slow roll technique, Examples of Inflationary models. Dark matter and Dark energy.

Astrophysics: Gravitational collapse, White Dwarfs, Chandrasekhar mass limit, Neutron stars, pulsars, Black holes, Schwarzschild and Kerr Black holes, event horizon, ergosphere and i.r.s.

Unit V

Nonlinear Electronic circuits and Systems: Emulating nonlinear differential equation with electronic circuits. Chaotic electronic circuits.

Antenna basics: Dipole antenna, Power propagation.

μwave vacuum tube devices:

Reflex Klystron and multi cavity Klystron, TWT Amplifier, Magnetron.

Microwave solid state devices:

Tunnel Diodes, Gun diodes, varactor diodes, HEMT, IMPATT diode.

Characteristics of optical emission, LED: Power and quantum efficiency calculation, Structure of LED, Hetero-junction LED, Photo diode: PIN and APD photodiode, and hetero junction diode, Phototransistor, Photo conductors, Quantum well laser, opto-couplers, Shot noise.

Fiber optics:

Optical fibre, Fiber materials, Drawing process, step and graded index fibres, ray propagation, Modes in optical fibres: multi-path dispersion, single mode fibre- working principle, Multimode fibre, Group velocity dispersion, Directional coupling, Optical soliton.

Optical amplifiers and nonlinearity:

Semiconductor Optical Amplifier, XGM, SPM, XPM, Four wave mixing. EDFA.

Unit VI

Nonlinear Optics and application:

Nonlinear optical effects; Second and third order nonlinearities; Harmonic generation; Generation of tunable radiation (Sum, Difference Frequency and Optical parametric oscillators); Light detection and ranging (LIDAR), Optical phase conjugation; Generation, detection and measurement of ultrafast pulses.

Nonlinear Crystals:

Growth techniques and properties of different UV to IR transmitting crystals.

Laser Cooling and BE Condensation:

Principle of laser cooling and trapping, optical molasses, cooling below Doppler limit, magnetic trapping, applications.

Unit VII

Shell Model: Mean field concept, Two-state and multistate mixing, Residual interaction, Pairing correlation, M-scheme calculation, Configuration mixing. Shell model spectroscopy and spectrum of ^{18}O and ^{19}O. Many-particle shell model.
Collective Model: Qualitative discussion on vibrational, rotational and Nilsson models. Interacting boson model - basic ideas, Hamiltonian, group chains and eigenvalues.
Nuclear Structure at extremes of stability: Theoretical concepts and extrapolations, Drip line physics.

Course code: PHDCW 104

Term paper(s) & Seminar Presentation(s)

Distribution of marks

Preparation:	25
Seminar Presentation & Viva voce:	25

Reference Books

1. Principles of Quantum Mechanics, R. Shankar, Springer (1994)
2. Quantum Mechanics, Leonard I. Schiff, McGraw –Hill Kogakusha Ltd. (1968)
3. Relativistic Quantum Mechanics, James D. Bjorken and Sidney D. Drell, McGraw Hill Book Company (1965)
4. Quantum Field Theory, Lewis H. Ryder, Cambridge University Press (1985)
5. Quantum Theory of Many Particle Systems, John D. Walecka and Alexander L. Fetter, McGraw-Hill
6. A First Book of Quantum Field Theory – A. Lahiri and P. B. Pal, Narosa Publishing House (2001).
7. Optoelectronics and Fiber Optic Communication, D C Sarkar and C K Sarkar, New Age.
8. Photonics : A Yariv and P Yeh. Oxford.
9. Optical Electronics : By Ghatak and Thyagrajan , Cambridge University Press.
10. Sensors and Transducers (2 nd Edn), D. Patranabis, PHI Learning Pvt. Ltd., New Delhi 2009.

11. Communication Electronics, Control Theory, High frequency Devices: Electronic Communication Systems, Kennedy, TMH.
12. Communication systems, Lathi, Oxford Electronic communication Systems.
13. Electronics Communication, Roddy and Coolen, Pearson.
14. Microwave Devices and Circuits, Liao, Pearson.
15. Microwave, Sisodia and Gupta, New Age.
16. Solid State Laser Engineering: W Koechner (Springer)
17. Handbook of Nonlinear Optics: R L Sutherland (Marcel Dekker, Inc.)
18. Modern Spectroscopy: J M Hollas (Wiley)
19. R.F. Casten: Nuclear Structure from a Simple Perspective (Oxford University Press)
20. K. Heyde: Basic Ideas and Concepts in Nuclear Physics (Institute of Physics Publishing)
21. D.J. Rowe and J.L. Wood: Fundamentals of Nuclear Models (World Scientific)
22. S.N. Mukherjee: Elements of Nuclear Theory (CBS Publishers)
23. S.S.M. Wong: Introductory Nuclear Physics (PHI)
24. C R Kothari, Research Methodology: Methods and Techniques, New Age International (P)Ltd. (2010) , New Delhi
25. Inderpal Singh, Research Methodology and Statistical Methods, Kalyani Publishers, Ludhiana.
26. Textbook of Research Ethics, By Sana loue, https://link.springer.com
27. Handbook of Research Ethics & Scientific Integrity, R. Iphofen, Springer (2019).