BERHAMPUR UNIVERSITY

Syllabus

For

M.Phil/Pre PhD

PG Department of Physics

Berhampur University,

Berhampur-76007(Odisha)

2020

Revised M.Phil/Pre-PhD Syllabus

Effective from 2020

Objective of the Course: The MPhil/Pre PhD is offered by the Department of Physics as a full-time course and introduces students to research methodologies, ethics and specialist knowledge. Its main aim is to give students the opportunity to acquire or develop skills and expertise relevant to their research interests.

SEM	CORSE	COURSE TITLE	HRS PER WEEK	CREDIT	EXAM HRS	MARKS	Total
First	PHYS MPC1	Research Methodology	4	4	3	80(END SEM)+20 (INTERNAL)	100
	PHYS MPC2	Advanced Experimental Techniques in Physics	4	4	3	80(END SEM)+20 (INTERNAL)	100
	PHYS MPC3	Research and Publication Ethics	2	2	2	40(END SEM)+10 (INTERNAL)	50
	PHYS MPS1	Seminar Presentation		2			50
	PHYS MPE1 PHYS MPE2 PHYS MPE3	Solid State Physics Nuclear Physics Particle Physics	4	4	3	80(END SEM)+20 (INTERNAL)	100
Second	PHYS MPS2	Review of Research Progress through PPT		4		100	100
	PHYS MPD1	Dissertation		12		300	300

Note: Pre PhD students have to register for 16 credits, while M.Phil students have to register for 32 credits

Sub Code: PHYS MPC1	RESEARCH METHODOLOGY	
Semester:1	**Credit:4**	**Core Course**
Pre-requisites: Basic understanding of Numerical Analysis, Green's Function		

Objectives:

- ✔ **To get a way to systematically solve research problems.**
- ✔ ***Aims to give the work plan of research.***
- ✔ ***To give training in choosing method materials, scientific tools and techniques relevant to the solution of the problem.***

PHY-C-101: RESEARCH METHODOLOGY

UNIT-1

Motivation and Objectives of Research; Types of Research; Research Approaches; Significance of Research; Research Methods vs. Methodology; Research and Scientific Method; Research Process; criteria of good research. **10 Hours**

UNIT-2

Meaning of Research Design; Need for Research Design; Features of a Good Design; Concepts Relating to Research Design; Basic Principles of Experimental Design; Different Research Design.

Methods of Data Collection:- Primary and Secondary Data Collection;

Report Writing:-Significance of Report Writing; Different steps in Writing a Report; Layout of a Research Report; Types of Report; Oral Presentation; power-point presentation. **10 Hours**

UNIT-3

Document Preparation by Latex-2£; Basic of Latex File; Command Name and Arguments; Environment; Declaration; Length; Special Character; Document Class; Standard Class Option; Page Style; Title Page; Tables; Mathematical Environment; Constant and Variable; Exponent and Indices; Fraction; Roots; Mathematical Symbols; Binary Operations; Relations; Function Names; Matrix. **10 Hours**

UNIT-4

In homogeneous problems, Green's function: - Solution of Sturm-Liouville Differential Equation; Solution of Simple Harmonic Oscillator; Circular drum problem; Green's function in electrodynamics.

Integral equation: -Classification; Degenerate Kernels, Neumann and Fredholm series. **10 Hours**

UNIT-5

Numerical Methods: - Differences of a Polynomial, forward differences, Newton's forward and Backward Interpolation; Newton's formulae for Backward interpolation ; Interpolation with Unequal Differences:- Divided differences; Relation between Divided Differences and Simple Differences ; Newton's General Interpolation formula; Lagrange's Interpolation Formula; Numerical integration:- A general Quadrature formula for Equidistant Ordinates; Simpsons Rule; Weddle's Rule the Trapezoidal Rule; solution of differential equation equations numerically:- The Runga-Kutta method 1^{st} order and 2^{nd} order only.

Graefe's Root Square Method for Solving Algebraic Equations:- Principles of the Method ; Root Squaring Process; All Real and Equal Roots**.** **10 Hours**

BOOKS

1. Mathematical Methods of Physics by Mathews and Walker (chapter 9 and 11)
   W.A Benjamin, INC, California.
2. Numerical Mathematical Analysis by J.B. SCARBOROUGH
   Oxford and IBH Publishing Co.
3. Research Methodology: Methods and Techniques, Kothari, C.R.(2008), Second Edition .New Age Publishers, New Delhi.

REFERENCE BOOK

4. Introductory methods of numerical Analysis by S.S. SASTRY
   Prentice-Hall of India.

Sub Code: PHYS MPC2	Advanced Experimental Techniques in Physics	
Semester:1	Credit:4	Core Course
Pre-requisites: Basic Solid state physics, Nuclear Physics and Particle Physics		
Objectives: ✔ To learn *about various data analysis methods/tools related to experimental physics* ✔ *To get good exposure of experimental methods in solid state and high energy physics.*		

Unit I: Data Analysis

(10 hours)

Line Shapes in Spectroscopy: Lorentzian and Gaussian Fitting of the spectras (curve fitting) Deconvolution of spectrum, Derivative peak shapes. Some examples of generating spectra and analysis of spectra by taking examples of X-ray photo-electron spectra. Software/analysis using Origin.

Unit 11:Measurement methods.

(10 hours)

Resolution of spectrometer/ instrument (General): Resolving power and influence of different experimental parameters on it. Sensitivity of Measurement. Accuracy of measurements. Instrumental errors and measurement errors. (static& dynamic) Examples of UV-vis-NIR, IR, XRD spectra, vis-a-vis Instrumental parameter like slit width, relaxation time, scan speed etc.

Unit III: Compositional analysis.

(10 hours)

Atomic absorption, emission spectroscopy - fundamental of optical atomic spectrometry, Atomic emission spectroscopy. Atomic fluorescence spectrometry. Comparison of Atomic spectroscopies. UV-vis-NIR absorption spectroscopy, Electronic transition in solids,

Transmission reflection and absorption coefficient Infrared spectroscopy, Molecular vibration spectroscopy, Rotational spectroscopy, Bond analysis. Raman spectroscopy.

Unit IV:**Crystal structural and microstructure analysis.**
(10 hours)

X-ray diffraction principles, Type of the cameras. Intensity dependence. Rietveld analysis for powder diffraction. Particle size determination using Scherrer formula, Microstructure analysis. Scanning electron and Transmission electron microscopy, Field emission microscopy, scanning Tunneling microscopy, Atomic force microscopy. Analysis of experimental results.

Unit V: Detectors and Accelerators.
(10hours)

Introduction, Gas-filled Ionization Detectors, Proportional Counters, Geiger-Muller Counter, Cherenkov Detectors, Basic Principles of Accelerators, Classification of Accelerators, Basic Components and Ion Sources, Applications of Accelerators, Linear Accelerators, Orbital Accelerators (Conventional Cyclotrons), Synchro Cyclotrons, Isochronous Cyclotrons (AVF/SFC Cyclotrons), Electron Synchrotron, Proton Synchrotron, Large Hadron Collider.

Reference Books

1. Methods of experimental Physics, M.I. Pergament, CRC Press, Taylor and Francis

2. Experimental Methods in Physical science, Editor Anita Kuch, Elsevier

3. Characterization of Materials, John B. Watchman (Butlerworth-Heinemann Manning Greenwich)

4. Introduction to Nuclear and Particle Physics: Ashok Das, Thomas Ferbel, John Wiley & sons.

5. Fundamentals of Nuclear Physics- Jahan Singh, Pragati Prakashan.

Sub Code: PHYS MPC3	Research and Publication Ethics.	
Semester:1	Credit:2	Core Course
Objectives: ✔ Awareness about publication ethics and publication misconducts		

THEORY

- **RPE 01: PHILOSOPHY AND ETHICS (3 hrs.)**

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

- **RPE 02: SCIENTIFICCONDUCT (5hrs.)**

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data

- **RPE 03: PUBLICATION ETHICS (7 hrs.)**

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 contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

PRACTICE

- **RPE 04: OPEN ACCESS PUBLISHING(4 hrs.)**

1. Open access publications and initiatives
2. SHERPA/RoME0 online resource to check publisher copyright & self-archiving policies
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

- **RPE 05: PUBLICATION MISCONDUCT (4hrs.)**

A. Group Discussions (2 hrs.)

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 (2 hrs.)

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

- **RPE 06: DATABASES AND RESEARCH METRICS (7hrs.)**

A. Databases (4 hrs.)
1. Indexing databases
2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics (3 hrs.)
1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite
Score
2. Metrics: h-index, g index, il 0 index, altmetrics

References

Bird, A. (2006). Philosophy of Science. Routledge.
MacIrityre, Alasdair (1967) A Short History of Ethics. London.
P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN:978-9387480865
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.
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.m
Beall, J. (2012). Predatory publishers are corrupting open access.

Nature,489(7415), 179-179.
https://doi.org/10.1038/489179a
Indian National Science Academy (INSA), Ethics in Science Education,Research and Governance(2019), ISBN:978-81-939482-1-7.
http://www.insaindiaxes.in/pdf/Ethics Book.pdf

Sub Code: PHYS MPS1	**SEMINAR PRESENTATION**	
Semester:1	**Credit:2**	**Core Course**
Pre-requisites: As per the concerned Supervisor		
Objectives: ✔ **To learn literature survey, writing project report.** ✔ **To improve communication skill delivering presentation.**		

Preparing a report on at least 05 research papers. Presenting the research reviewed papers through PPT.

Sub Code: PHYS MPE1		SOLID STATE PHYSICS
Semester:1	Credit:4	Core Course
Pre-requisites: Solid state Physics Special Paper in Post graduate level.		
Objectives: ✔ To learn advanced theories in solid state physics such as k.p method, Representation theory, interaction picture perturbation theory, Hubbard Model, and Anderson's Hamiltonian. ✔ *To apply the above theories to solve physical problems.*		

Unit-I

Energy bands, Properties of Bloch functions, Luttinger-Kohn wavefunctions and $\vec{k}.\vec{p}$ method(**k** is electron wave vector and **p** momentum), Two band model in the $\vec{k}.\vec{p}$ method, Electronic Density of States and Specific Heat. 10 Hours

Unit -11

Representation Theory: Crystal Momentum representation (CMR), Effective Mass Representation (EMR), Wannier functions, Local Representation(LR) 10 Hours

Unit-111

Aspects of electron-electron Interaction, ,single particle Green's function at T=0K, Two particle Green's function, Equations of motion, The interaction picture-perturbation theory 10 Hours

Unit-IV

Hubbard Model, Atomic Limit of Hubbard model, Transition from Atomic Limit to Band Limit 10 Hours

Unit-V

Anderson Hamiltonian, Hartree-Fock Solution, Solution of equation of motion, Existence of localized moments, Limiting cases, Susceptibility and Specific Heat 10Hours

Books:

1.Book: Quantum Theory of Solid State by J. Callaway, 1st Edition
2.Theoretical Solid State Physics by Jones and March
3.Greens's function for Solid State Physicists by Doniach and Sondheimer

Sub Code: PHYS MPE2	**NUCLEAR PHYSICS**	
Semester:1	**Credit:4**	**Elective Course**
Pre-requisites:1. Quantum Mechanics in Post Graduate Level. 2.Basic Nuclear Physics in Post Graduate Level		
Objectives: ✔ **To us the concepts of basic nuclear physics to advance level nuclear physics in the microscopic level to understand the origin of Universe.**		

UNIT-I

1. Basics of Shell Model, Hartree-Fock, Pairing, Rotational and Vibrational Spectra, Giant Resonance, Halo Nuclei. 10 Hours

UNIT-II

2. Nuclear Reactions, Potential Scattering, formal theory of reaction resonances and compound nucleus, direct reactions (inelastic stripping, pickup etc)extracting nuclear information from reactions, dissipation and fluctuation. 10 Hours

UNIT-III

3. Nuclear Matter A:

The independent particle approximation, The independent pair approximation, The Bethe-Goldstone approximation, Energies and wavefunctions in the independent pair approximation. 10 Hours

UNIT-IV

Nuclear Matter B:

The solution of Bethe-Goldstone equation, Properties of Nuclear Matter with realistic potential The energy gap in nuclear matter, Neutorn Star (elementary ideas). 10 Hours

UNIT-V

Quark models, (bag), quark equation of state, relativistic heavy ion collision, signature of QGP 10 Hours

Books:

1. Structure of Nucleus by Preston and Bhaduri
2. Theoretical Nuclear Physics by Blatt and Weisskoff
3. Buclear Structure by Bohr and Mottelson
4. Nuclear Models by Geiner and Eisenberg
5. Physics of Quark Gluon Plasma-Muller
6. Theory of Nuclear Reactions by P. Fröbrich and R. Lipperheide
7. Theoretical Nuclear Physics-Vol-I, Nuclear Structure by Amos De Shalit,Herman *Feshbach*

Sub Code: PHYS MPE3	**PARTICLE PHYSICS**	
Semester:1	**Credit:4**	**Elective Course**
Pre-requisites: 1.Relativistic Quantum Mechanics and Field theory 2. Particle Physics in Post Graduate Level		
Objectives: ✔ **To learn advanced theories in particle Physics such as Electro-weak theory, The Higgs Mechanism, the Weinberg-Salam Model, Form factors for the proton and neutron etc.** ✔ ***To apply this above theories to solve physical problems and that* explains the visible universe from the smallest to the largest scales**.		

Unit I:

Classification of matter: Quarks and Leptons , Symmetries of Lepton and Quarks, Particle representation in flavor SU(3) , Application of flavor SU(3): SU(3) invariant BPP and VPP coupling, Mass splitting in Flavor SU(3), Gell-Mann-OKubo mass formula, SU(6) wave-function for Mesons and Baryons, Magnetic moment of Baryons, Evidence of color, Colour confinement and hadronic states. 08 hrs.

Unit II:

Gauge Principle: Introduction to Gauge theory of fundamental interactions, Global and Local Gauge principle: U(1) local gauge: electromagnetic interaction QED (Quantum Electro dynamics), SU(2) local gauge : weak interaction and SU(3) local gauge QCD (Quantum Chromodynamics). Massive gauge bosons, Basic concept of spontaneous symmetry breaking and Higgs mechanism. 08 hrs.

Unit- III:

Electron scattering by external potential, influence of proton recoil, Influence of finite extension and anomalous magnetic moment of proton, Form factors for the proton and neutron. 08 hrs.

Unit-IV-

Weak Interactions: V – A structure of the weak interaction , Parity and Chiral structure of the weak interaction, Experimental evidence for V – A , Nuclear beta decay, Fermi Theory of beta decay, Form of beta decay Hamiltonian, Parity violation in beta decay, Trace theorems, Decay width calculation for Pion and Muon. The weak interactions of quarks, The CKM matrix , The neutral Kaon system , Strangeness oscillations . 12 hrs.

Unit-V

Unification Theory : Gauge models of electro-weak unification, spontaneously broken symmetries, The Higgs Mechanism revisited, The Weinberg-Salam Standard Model. Test and prediction of standard model, Particle masses, Discovery of Higgs particle , Beyond the Standard model: shortcoming of the standard model : Theoretical motivation for massive neutrino in particle physics and Astrophysics, Neutrino flavor oscillation, Brief discussion on Left-right symmetric model and Grand unified Theory. 12 hrs.

BOOKS:

1. Introduction to Elementary Particles by D.Griffiths, John Wiley & sons.

2. Relativistic quantum field theory by J.D. Bjorken and S.D. Drell, Mc Graw-Hill Book Company.

3. An Introductory Course of Particle Physics, Palas.B.Pal. C.R.C. Press.

4. Elementary particle physics by Gasiorwicz, Addison-Wesley publishing Company

5. Elementary Particle Physics by G.Kallen, Addison-Wesley publishing Company

6. Quarks and Leptons: F.Halzen and A.D.Martin, John Wiley.

7. A Modern introduction to particle physics : Fayyazuddin and Riazuddin, World Scientific, Singapore.

8. Modern Elementary Particle Physics by G.Kane, Addison-Wesley Publishing Company.

9. T.-P. Cheng and L.-F.Li, “Gauge theory of Elementary Particle Physics’’Oxford University Press.

10. Mark Thomson " Modern Particle Physics " Cambridge University Press.

SEMESTER -2

PHYS MPS2: Review of Research Progress through PPT-4 Credits

Preparing a Review report related to dissertation. Presenting the research reviewed papers through PPT.

PHYS MPD1 Dissertation: 12 credits

Specializations:

- ✔ Solid State Physics(Theory and Experiment)
- ✔ Particle Physics(Theory)
- ✔ Nuclear Physics(Theory)
- ✔ Photonics(Experiment)

A student can carry out dissertation in any one of the area mentioned above depending on the availability of the faculty members in the specialization.