P.G. DEPARTMENT OF PHYSICS

# SYLLABUS FOR THE Ph.D. /EXECUTIVE Ph.D. COURSE WORK IN PHYSICS

**FOR THE SESSION 2023 ONWARDS**

# Ph.D. /Executive Ph.D. Course Work in Physics for 2023 onwards

**Approved by BOS on Dt. 09.10.2023**

| | **One Semester (Six months)** | | | |
|---|---|---|---|---|
| **Code** | **Name** | **Type** | **Mark (Int + End Term)** | **Credit** |
| **PHY-701** | Research Methodology & Computer Application | Theory | 40+60=100 | 06 |
| **PHY-702** | Theoretical Physics | Theory | 40+60=100 | 06 |
| **PHY-703** | Research and Publication Ethics | Theory | 20+30=50 | 02 |
| **PHY-704** | Literature Review (Including Book Review related to the proposed topic) [Nano science and Instrumentation/ Introduction to Quantum Tunneling & Nuclear Reactions/ Gravitation and Cosmology/ Condensed Matter Physics / Introduction to Relativistic Heavy-Ion Collision] | Project | 100 | 06 |
| **PHY-705** | Preparation of Research Proposal/ Synopsis | Project | 50 | 04 |
| | Total | | 400 | 24 |



## Marking Pattern:

| **Paper Type** | **Internal Evaluation** | | | **End Term Examination** | | | **Total** |
|---|---|---|---|---|---|---|---|
| | **Home Assignment** | **Quiz** | **Written (Internal)** | **Written (End Term)** | **Report** | **Viva-Voce** | |
| **Theory (PHY-701, 702)** | 10 | 10 | 20 | 60 | NA | NA | 100 |
| **Theory (PHY-703)** | 10 | 10 | NA | 30 | NA | NA | 50 |
| **Project PHY-704** | NA | NA | NA | 20 (Presentation) | 60 | 20 | 100 |
| **Project PHY-705** | NA | NA | NA | 10 (Presentation) | 30 | 10 | 50 |

**Board of Examiners:**

| Sl. No. | Section | Examiner(s) |
|---|---|---|
| 01 | Home Assignment | Internal Course Teacher/ Instructor from the Department |
| 02 | Seminar Presentation/Practice (Paper: Phy-701,702,703) | Faculty Members of the Department, as nominated by the Head of the Department |
| 03 | Seminar Presentation (Paper: Phy-704,705) | Faculty Members of the Department, as nominated by the Head of the Department including the RAC. The proposed Supervisor, if from outside the University Campus, may be co-opted as a member examiner. |
| 04 | Written (Internal) | Internal Course Teacher/ Instructor from the Department |
| 05 | Report | Department Research Committee (DRC) and Research Advisory Committee (RAC) |
| 06 | Viva-Voce | Department Research Committee (DRC) and Research Advisory Committee (RAC) |
| 07 | Written (End Term) | Examiner as appointed by the Board of Studies |

For Executive Ph.D. Course work, all classes are conducted in blended mode. Examination will be conducted in holidays as per the convenient of selected candidates.

## PH.D. IN PHYSICS

## PROGRAM OUTCOMES (POs)

After completing Ph.D. Program, students are able to

| | |
|---|---|
| **PO1** | Pursue their careers in Research, Academics and Industries. |
| **PO2** | Carry out Scientific investigation without being biased. |
| **PO3** | Demonstrate and maintain the highest standard on ethical issues in their social and professional life |
| **PO4** | Use their experimental skill and theoretical knowledge to start their own startup program and take initiatives to be an entrepreneur to meet the societal needs and environmental challenges. |
| **PO5** | Write a project proposal by identifying recent scientific problem. |

## PROGRAM SPECIFIC OUTCOMES (PSOs)

After completing Ph.D. Physics Program, students are able to

| | |
|---|---|
| **PSO1** | Know the ongoing scientific research in Nuclear Physics/ High Energy Physics/ Radiation Physics/ Condensed Matter Physics/Cosmology/ Astrophysics/ Material Science. |
| **PSO2** | Handle advanced scientific instruments used in Physics Laboratories. |
| **PSO3** | Review a topic by searching published journal articles. |
| **PSO4** | Supervise postgraduate students for selection of topics for their project work. |
| **PSO5** | Understand the role Physics in society |

**Paper : Research Methodology & Computer Application** **Semester Mark : 60**

**Internal Mark : 40**

**Code : PHY-701** **Total Mark : 100**

**Credit-06**

**Objectives/Course Philosophy:**

- To show the Ph.D. scholars standard procedures of research from the beginning to the end and their complexity;
- To inform and equip the scholars with essential numerical and computer knowledge for conducting research before landing up in the field.

**Unit-I:**

**Research Concepts & Design:** Objectives of Research, Research Approaches, Types of Research, Research Process, Research Proposal, Need, Concepts and different Research Designs, Research methods and identification of problem

**Data Collection Techniques:** Primary and secondary data, Methods of collecting primary data, Sources of secondary data, Processing and analysis of data.

**Unit-II:**

**Statistics in Research:** Measures of central tendency, Measures of Dispersion, Measure of Asymmetry (Skewness), Measures of Relationship, Simple Regression Analysis, Chi-Square Test for comparing a variance to a theoretical variance.

**Thesis Writing:** Writing of thesis and report, its framework, essentials and presentation.

**Unit III :**

**Numerical Techniques used in computing :** Approximation and Errors in Computation, Roots of Nonlinear equations, Solution of linear systems by Matrix method, Empirical laws and Curve fitting, Numerical Differentiation and Integration, Numerical solution of Ordinary and Partial Differential Equations, Boundary-value and Eigen-value problems.

**Unit IV:**

**Tools of Modern Computing:** Computer algebra System (CAS) and its use as calculator. Computing Functions, Making Graphs and Simple Programming using different Mathematical Software like MAPLE, MATHEMTICA and MATLAB etc.

**Python**: Introduction, statements, Built-in data types, Functions and Classes

**Unit V:**

**Writing with LATEX:** Basic information**,** Create and typeset a simple LATEX document, elementary mathematical typesetting, Use of Graphics, Advanced mathematical type setting

**RECOMMENDED BOOKS:**


1. Research Methodology: Methods & Techniques by C.R. Kothari, 3rd Ed. New Age Int. Pvt.Ltd.
2. Research Methodology-A step by step Guide for Beginners- Ranjit Kumar, Pearson Education, Singapore
3. Thesis and Assignment Writing – J Anderson, B.H. Burston and M. Poole, Wiley Eastern (1977)..
4. Report Writing by C.G. Gaum& H.F. Graves, PHI, 3rd Ed.
5. Fundamentals of Statistics by S.C. Gupta, Himalaya Publishing.
6. Practical Research: Planning & Design, by Paul D. Leedy, Prentice Hall
7. A First course in Computers, by Sanjay Saxena, VIKAS Publications 2011
8. MATLAB Demystified By K KSarma, VIKAS Publications 2011
9. A Student's Guide to the study, Practice and Tools of Modern Mathematics – D. Bindner and M. Erickson (2011)
10. Numerical Methods and Statistical Techniques using 'C'- Manish Goyal (2009)
11. 11,Numerical Methods in engineering & Science – B. S. Grewal (2009)
12. Python basics, S.R. Doty (2008)
13. Learning to Program with Python, Richard L. Halterman
14. A Python Book: Beginning Python, Advanced Python, and Python Exercises, Dave Kuhlman


**Course Outcomes:**

| | |
|---|---|
| **CO1** | Understand the research concepts and different research designs and also learn different techniques of data collection |
| **CO2** | Learn about the statistical methods useful in research and about the framework and essentials of thesis writing. |
| **CO3** | Acquire the knowledge of various numerical techniques used in computing. |
| **CO4** | Use various tools of modern computing like MAPLE, MATHEMATICA, MATLAB and PYTHON. |
| **CO5** | Use advanced writing tools LATEX |

**Course Articulation Matrix:**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 1 | 3 | 3 |
| **CO2** | 2 | 3 | 1 | 2 | 3 |
| **CO3** | 3 | 3 | 0 | 2 | 2 |
| **CO4** | 3 | 2 | 0 | 2 | 2 |
| **CO5** | 3 | 2 | 0 | 2 | 3 |

**0: No Correlation, 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High)**

**Paper : Theoretical Physics** **Semester Mark : 60**
**Code : PHY-702** **Internal Mark : 40**
**Total Mark : 100**
**Credit- 06**

**Objectives/Course Philosophy:**

- To refresh the Ph.D. scholars about the general theoretical physics before beginning of advance research in Physics

**Unit I:**
**Mathematical Methods:** Vector Calculus, Special functions and applications (Hermite, Bessel, Laguerre and Legendre functions), Fourier series, Fourier and Laplace transforms. Elements of complex analysis, analytic functions, partial differential equations (Laplace, wave and Heat equations in 2D and 3D dimensions)
**Classical Mechanics:** Rigid body dynamics, moment of inertia tensor, Non-inertial frames, pseudoforces, small oscillations, normal modes, Variational principle, Generalized coordinates, Lagrangian and Hamiltonian formalism and equations of motion, phase space dynamics.

**Unit-II:**
**Quantum Mechanics:** Schrodinger equation, Hydrogen atom, Eigen value problems (particle in a box, harmonic oscillator in 3D, etc.), Tunneling through a barrier, Time independent perturbation theory and applications, WKB approximation
**Thermodynamics and Statistical Physics:** Phase space, micro and macro states, micro-canonical, canonical, grand canonical ensembles and partition functions, thermodynamical functions, classical and quantum statistics, Ideal Bose and Fermi Gases, Bose-Einstein condensation

**Unit III:**
**Electrodynamics:** Electric fields, potentials, Maxwell's equations in free space and linear isotropic media, boundary conditions on the fields at interfaces, Dynamics of charged particles in static and uniform electromagnetic fields, Electromagnetic waves, Radiation from moving charges and dipoles and retarded potentials.
**Electronics and Experimental methods:** Semiconductor devices, diodes, junctions, Field effect devices, Opto-electronic devices, Operational Amplifiers and their applications, Digital techniques and applications, Microprocessors and microcontrollers

**Unit IV:**
**Atomic & Molecular Physics:** Quantum states of an electron in an atom, Spectrum of Helium and alkali atoms, hyperfine structure and isotope shift, width of spectrum lines, LS and jj coupling, Zeeman, Electronic, rotational, vibrational and Raman Spectra of diatomic molecules, selection rules, Lasers-Optical pumping.
**Nuclear Physics:** Basic nuclear Properties, Binding Energy, Alpha, Beta and Gamma decays, Liquid drop model, nucleon-nucleon potential, Deuteron problem, Shell model, Rotational Spectra, Fission and Fusion, Nuclear reactions, Compound nuclei and direct reactions

**Unit V:**
**Particle Physics:** Application of symmetry arguments and conservation laws to particle decays and reactions, Application of symmetry arguments to particle reaction, Relativistic kinematics

**Condensed Matter Physics:** Bravais lattices, Reciprocal lattice, Diffraction and structure factor, phonons, lattice specific heat, free electron theory and electronic specific heat, Drude model of electrical and thermal conductivity, electron motion in periodic potential, band theory of solids: metals, insulators and semi conductors, superconductivity

**RECOMMENDED BOOKS:**


1. Solitons an Introduction by P.G. Drazin and R.S. Johan (Cambridge Univ. Press, 1989)
2. Chaos in Dynamical Systems by E. Ott (Cambridge Univ., Press, 1993)
3. Solitons and Instantons by R. Rajaraman (North Polland. 1989)
4. Gauge theory of Elementary Particles by T.P. Cheng and Li (Oxford)2000
5. Structure of the Nucleus by M.A. Preston and R.K. Bhadhuri.
6. Quantum Theory of Solids by C.Kittel
7. Liquid State Physics by Engelsta
8. Quantum field theory by Lahiri and Pal
9. The chemical evolution of the galaxy by F. Matteucci
10. Planetary Science by I. Pater and J.J. Lissauer
11. Solar system evolution: A new perspective by S.R. Taylor
12. Relativistic Kinematics by R. Hagedon.
13. Statistics for Nuclear and Particle Physicists by Louis Lyons. 500726
14. Nuclear spectroscopy and reactions (part A & C) edited by Joseph Cerny.
15. Radiation detection and measurements by Glenn. F. Knoll.
16. Gamma-ray and electron spectroscopy in Nuclear Physics by H. Ejiri and M.J.A. de Voig
17. The electromagnetic interaction in Nuclear Spectroscopy, Edited by W.D. Hamliton.
18. Alpha, Beta-and Gamma-ray Spectroscopy, Vol 1 and 2, Edited by Kal Siegbahn.
19. X-rays in Atomic and Nuclear Physics by N.A. Dyson
20. Thin Films Phenomena by K.L. Chopra
21. Science of Engineering Materials by C.M. Srivastava and C. Srinivasan, Wiley East. Ltd.
22. Nanoparticles and Nanostructured Films-Preparation, Characterization and Applications: J.H. Fender (Wiley).
23. Characterization of Semiconductor Materials by Philips F. Kare and Greydon B. Lausbee, Mc Graw Hill.
24. Physical methods for Materials Characterization by P.E.J. Fiewitt & R.K. Wild.
25. Optical Properties of Solids by M. Fox, Oxford University Press. Fortran Programming – V. Rajaraman
26. Instrumental Methods of Analysis, Willard Merritt, CBS publishers, 2005
27. Material Science & Engineering: An Introduction by William D. Callister, JWS, Newyork.
28. Solid State Physics, C. Kittel, Wiley- Eastern.
29. Electron Microscopy in the Study of Materials', Arnold M Prutton, 'Surface Physics', 2nd Ed., Clarendon
30. X-ray Diffraction, B.E. Warren, Addison-Wesley Publishing Co. Reading, MA, 1969


**Course Outcomes:**

| | |
|---|---|
| **CO1** | Remember the fundamental concepts of mathematical methods and classical mechanics |
| **CO2** | Remember the fundamental concepts of Quantum mechanics and statistical physics |
| **CO3** | Remember the fundamental concepts of Electrodynamics and Electronics. |
| **CO4** | Remember the fundamental concepts of Atomic, Molecular and Nuclear Physics |
| **CO5** | Remember the fundamental concepts of Condensed matter physics and particle physics |

**Course Articulation Matrix:**

| | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 0 | 1 | 1 |
| **CO2** | 3 | 3 | 0 | 1 | 1 |
| **CO3** | 3 | 3 | 0 | 1 | 1 |
| **CO4** | 3 | 3 | 0 | 1 | 1 |
| **CO5** | 3 | 3 | 0 | 1 | 1 |

**0: No Correlation, 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High)**

**Paper: Research and Publication Ethics** **Semester Mark: 30**
**Code : PHY-703** **Internal Mark: 20**
**Total Mark: 50**
**Credit: 02**

**Objectives/Course Philosophy:**

- To aware the Ph.D. scholars about research publication ethics and publication misconducts

**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

**Unit-IV (Practice)**

**Open Access Publishing:**

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

**Unit-V (Practice)**

**Publication Misconduct:**

A. Group Discussions: Subject specific ethical issues, FFP, authorship, conflicts of interest, 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.** Database: Indexing databases, citation databases: Web of Science, Scopus, etc
**B.** Research Metrics: Impact factor of Journal as per journal citation Report, SINP, SJR, IPP, Cite Score, Metrics: h-index, g index, i10 index, altmetrics

**RECOMMENDED BOOKS:**


1. Philosophy of Science, Routledge, A. Bird, 2006
2. A short History of Ethics, London, MacIntyre, Alasdair (1967)
3. Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN:978-9387480865.
4. On Being a scientist: A Guide to Responsible Conduct in Research: Third Edition. National Academies

Press, National Academy of Sciences, National Academy of Engineering and Institute of Medicine (2009)
5. 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.cfm, Resnik, D. B. (2011).
6. Predatory publishers are corrupting open access. Nature, J. Beall (2012) 489 (7415), 179-179, https://doi.org/10.1038/489179a
7. Ethics in Science Education, Research and Governance (2019), Indian National Science Academy (INSA), ISBN: 978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics_Book.pdf

**Course Outcomes:**

| | |
|---|---|
| **CO1** | Understand the moral philosophy and ethics. |
| **CO2** | Understand the ethics with respect to science and research |
| **CO3** | Know about the publication ethics and Violation of publication ethics |
| **CO4** | Use of open access publishing resources |
| **CO5** | Use of plagiarism software and databases and research matrics. |

**Course Articulation Matrix:**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 3 | 1 | 2 |
| **CO2** | 2 | 3 | 3 | 1 | 3 |
| **CO3** | 3 | 2 | 3 | 1 | 2 |
| **CO4** | 2 | 2 | 3 | 1 | 3 |
| **CO5** | 2 | 3 | 3 | 1 | 3 |

**0: No Correlation, 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High)**

**Paper Code: PHY-704**
**Total Mark: 100**
**Credit:06**

**Objectives/Course Philosophy:**

- To show the Ph.D. scholars the method of literature review including book review.

**Course Outcomes:**

- After completion of the course a scholar will learn how to do literature review/book review of a given topic.

Literature Review (Including Book Review related to the proposed topic)
[Nano science and Instrumentation/Introduction to Quantum Tunneling & Nuclear Reactions/ Gravitation and Cosmology/ Condensed Matter Physics / Introduction to Relativistic Heavy-Ion Collision]

This Review paper shall be organized by the proposed teacher guide(s) who have offered to supervise Ph.D. work in a specialized area.

**Paper Code: PHY-705**
**Total Marks: 50**
**Credit: 04**

**Objectives/Course Philosophy:**

- To show the Ph.D. scholars the method of preparation of a proposal for research project.

**Course Outcomes:**

- After completion of the course a scholar will learn how to prepare synopsis/proposal for research.



Preparation of Research Proposal/ Synopsis