

VIVEK UNIVERSITY

[Estd. by Govt. of Uttar Pradesh, as per Uttar Pradesh Private Universities Act, 2019, no.21 of 2024.] MORADABAD ROAD, POST AGRI, BIJNOR, UTTAR PRADESH-246701, INDIA

Syllabus Pre-Ph.D. Course Work Physics

Effective from Academic Session (2024-2025)

Course Structure and the Assessment Scheme of

SN	Paper Code	Subject	Credits	Total	Total	Minimum
			L:1:P	credit	marks (External + Internal)	marks to be scored for successful completion
1		Research Methodology (Common for All)	3:1:0	4	60+40	50
2		Research & Publication Ethics (Common for All)	1:1:0	2	30+20	25
3		Quantitative Methods and Computer Applications (Common for All)	3:1:0	4	60+40	50
4		Advances in Theoretical Physics	3:1:0	4	60+40	50
5		Field work (Seminar/ workshop/ conferences/ literature review)	0:0:4	4	(0+100)	50
Total				18	450	225

Pre Ph.D. Course Work Syllabus

Note: 1. A Ph.D. scholar must attain a minimum of 55% marks in aggregate.

2. Internal marks shall be based on assignments/class activity/case study and other academic activities provided by course instructor.

Programme objectives:

- 1. Equip themselves with ethical issues related to Research and Publication.
- 2. Offer expertise, resources, and services to the community in the field of Physics
- 3. Proficiency with fundamental knowledge in several specialized areas of research and expertise in at least one area of research related to Physics
- 4. To contribute the advancement of knowledge and technology to enhance activities in Physics
- 5. Organize and conduct research (advanced project) in a more appropriate manner.

Programme Outcomes:

- 1. Deep understanding of fundamental and advanced physics principles.
- 2. Expertise in specialized field of theoretical physics.
- 3. Provide hands-on experience to carry out research work in Physics as well as interdisciplinary areas.
- 4. Develop the ability of critical thinking and problem-solving skills for independent research.

- 5. Knowledge and understanding of ethical standards in proposing, executing, and communicating scientific research.
- 6. Ability to communicate concepts and results to a technical audience in the form of conference papers, journal papers, and/or oral presentations etc.

Programme Specific Outcomes:

- 1. To develop rigorous understanding of fundamental and advanced topics in physics and related interdisciplinary fields.
- 2. Apply appropriate research methodology, tools & techniques for systematic investigation, data analysis and solving the problems.
- 3. Gain ability to apply knowledge of Physics to research in real-world issues.
- 4. Get familiar with current research trends in various core areas of Physics.
- 5. Leadership and self-reliance Impact leadership abilities to the students to lead and excel in their respective fields. Also, the training will make students self-reliant.

Paper-I: Research Methodology (Common)

Course objectives:

- 1. To understand some basic concepts of research and its methodologies & identify appropriate research topics.
- 2. Select and define appropriate research problem and parameters.

Course outcomes:

- 1. To familiarize the research scholar with the fundamentals of scientific research.
- 2. To develop understanding of the basic framework of research process.
- 3. To develop an understanding of various research designs and techniques.
- 4. To identify various sources of information for existing research and data collection.
- 5. To develop an understanding of the ethical dimensions of conducting applied research.
- 6. Apply the theoretical and experimental knowledge into research work.

Unit-I

• Scientific Research: Meaning, importance and characteristics of scientific research, validity in research, Selection and formulation of Research Problem, Research Design, Phases/stages in research; types of research- qualitative, quantitative, exponential, exploratory, empirical, descriptive, ex-post facto, case studies, historical studies, philosophical studies, quasi-experimental; ethical problems in research; constructs and variables- nature of construct and variables, concept of constructs, type of variables, continuous and categorical, constructs, observables and intervening variables; Review of literature- purpose of the review, sources of the review, preparation of index card for reviewing and abstracting.

Unit-II

• Methods of Research: General Survey of various methods including Survey Method, Interdisciplinary Method, Case Study Method, Sampling Method, Observation Method, Interview Method, Schedule Method, Questionnaire Method, Documentary Method, Library Method, Historical Method and Scientific Method. Characteristic Features of Scientific Method; Empirical Verifiable, Cumulative, Self - Correcting, Deterministic, Ethical & Ideological neutrality (Value Free).

Unit-III

• **Problem Identification and Hypothesis Formation:** Problem- meaning and characteristics of a problem, types of problem, generality and specific of problem; hypothesis- meaning and characteristics of a good hypothesis, types of hypotheses, formulating a hypothesis, ways of stating a hypothesis; testing experimental hypothesis-standard error, test of significance, level of significance, degrees of freedom, errors in hypothesis- type I, type II errors.

Unit-IV

• **Sampling and Research Design:** Meaning and types of sampling; probability and nonprobability sampling. Methods of drawing samples, requisites of a good sampling method, sample size, sampling error; meaning and purpose of research design, types of research design, criteria of a good research design, basic principles of experimental design.

Unit-V

• **Report Writing:** Meaning and significance of report writing, types of report, steps in writing report, layout of the research report, precaution in writing research report, developing thesis report, formatting, inside citations, references and bibliography. Locating Information on a Topic of Interest, Acquiring Copies of Articles of Interest, The Nature of Scientific Variables, Conceptual Versus Operational Definitions of Variables, Levels of Measurement, Various Paradigms, The Basic Format for a Research Report, Identification of the Parts of a Research Report, Citation and Referencing Styles, Essentials of Report Writing, Aids for Writing Good Research Report

Suggested Reading:

- Bagchi, Kanak Kanti (2007) Research Methodology in Social Sciences: A Practical Guide, Delhi, Abijeet Publications.
- Kothari, C.R (2004) Research Methodology: An Introduction, Delhi, New Age.
- Flyvbjerg, Bent (2001) Making Social Science Matter: Why Social Inquiry Fails and How it can Succeed Again, United Kingdom, Cambridge University Press.
- Goodde and Hatte (1952) Methods in Social Research, New York, McGraw Hill.
- Cooper & Schindler, Business Research Methods, Tata McGraw Hill.
- Broota, K.D., Experimental Designs in Behavioural Research, New Age International.
- Singh A. K., Test Measurement and Research Methods in Behaviours Sciences, Bharti Bhawan.

Paper-II: Research & Publication Ethics (Common)

Course objectives:

- 1. To understand the philosophy of science and ethics, research integrity and publication ethics research misconduct.
- 2. To understand indexing and citation databases, open access publications, research metrics (citations, h-index, impact Factor, etc.), predatory and clone Journals.

Course outcomes:

- 1. To develop an understanding of research ethics, publications misconduct and plagiarism.
- 2. To develop Intellectual honesty and research integrity as per committee of publication ethics.
- 3. To identify various sources of information for data bases and research matrices.
- 4. To develop an understanding of Open access publications and initiatives.
- 5. To understand the usage of similarity index tools.
- 6. Appreciate the components of scholarly writing and evaluate its quality

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

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

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 contributor ship, Identification of publication misconduct, complaints and appeals, Predatory publishers and journals Practice.

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

V. Publication Misconduct: Group Discussion, Subject specific ethical issues, FFP, authorship, Conflicts of interest, Complaints and appeals: examples and fraud from India and abroad. Software tools, Use of plagiarism software like Turnitin, Drillbit, iThenticate and other open-source software tools.

VI. Databases and Research Metrics: Databases, Indexing databases, Citation databases: Web of Science, scopus, etc., Research Metrics, Impact factor of journal as per journal Citation report, SNP, SJR, IPP, Cite score, Metrics: h-index, g index, i10 index, altmetrics.

Paper-III: Quantitative Methods and Computer Applications (Common)

Course objectives:

- 1. To gain familiarity about various data collection tools and techniques, data analysis and interpretation along with the application of computer and statistical software in research.
- 2. Application of various statistical and computer software's in research and development.

Course outcomes:

- 1. Analyse qualitative and quantitative data, and explain how evidence gathered supports or refutes an initial hypothesis.
- 2. Describe descriptive and inferential statistics techniques.
- 3. To apply the statistical techniques and computer software's for data analysing.
- 4. Develop research skills of administering research tools and data collection.
- 5. Able to locate the research studies available in the Internet and use of online journals and books,
- 6. Use computer techniques and software's for research & data analysing.

Unit-I

• Measurement and Scaling Techniques: Measurement in research, measurement scales sources of errors in measurement, tests of second measurement, techniques of developing measurement tools, meaning of scaling, scale classification bases, important scaling techniques, and scale construction techniques.

Unit-II

• Data Collection, Processing and Analysis: Methods of data collection – primary data, secondary data; primary data collection – observation method, interview method, questionnaires, schedules, guideline for constructing questionnaires/schedules, secondary data collection of, selection of appropriate method of data collection; coding, editing and tabulation of data, charts and diagrams used in data analysis, bar and pie diagrams and their significance; measures of central tendency, measures of dispersion; correlation and regression analysis - meaning and uses, methods of calculation of coefficients and their analysis and implication. sampling distribution, sampling schemes and sample sizes, confidence interval for the mean, t-statistic, z-statistic, confidence interval for the population variances, hypothesis testing, test of hypothesis for the population mean, population variance and ratio of two population variances; applications of z-test, t-test, f-test and chi-square test, association of attributes and techniques of testing, ANOVA.

Unit-III

• Fundamental knowledge of computer, statistical software and their application, application of statistical tests/techniques through the use of statistical software like SPSS, scientific packages like LISREL, AMOS, and SYSTAT for documentation and report generation.

Unit-IV

• Introduction to MS-Office: MS-WORD, MS-EXCEL, MATLAB, LATEX, MINITAB, R-programming. Applications of AI & ML in research.

Suggested Reading:

- Power Analysis for Experimental Research: A Practical Guide for the Biological, Medical and Social Sciences by R. Barker Baushell, Yu-Fang Li, Cambridge University Press.
- Chandan J. S., Statistics for Business and Economics, Vikas Publications.
- Broota, K.D., Experimental Designs in Behavioral Research, New Age International.
- Singh A. K., Test Measurement and Research Methods in Behavioral Sciences, Bharti Bhawan.
- Joyce Cox & Polly Urban, Microsoft Office, Galgotia Publishing.
- Sinha P.K., Computer Fundamentals, BPB Publishing.
- LaTeX: A Document Preparation System, 2/E Pearson Low Price Edition by Lamport.
- MATLAB: An Introduction with Applications by Gilat, Wiley India Pvt. Ltd.
- Getting Started with MATLAB by Rudra Pratap, Oxford University Press.

Paper-IV: Advances in Theoretical Physics

Course Objective:

To explore the recent advancement and current trends in areas of theoretical physics and related interdisciplinary fields to conduct independent research.

Course Outcomes:

- 1. To develop rigorous understanding of fundamental and advanced principles in topics like classical mechanics, quantum mechanics, nonlinear dynamics, statistical mechanics.
- 2. To master the mathematical framework of classical mechanics, quantum mechanics and statistical mechanics.
- 3. To gain proficiency in analysing and solving problems in nonlinear dynamics focusing on stability analysis, bifurcations and chaos in complex dynamical systems.
- 4. Learn to apply theoretical concepts to solve real-word problem in physics and related disciplines.
- 5. To foster critical thinking and research skills necessary for conducting independent research in theoretical physics.

Unit- I

 Classical Mechanics: Lagrangian formulation, Euler- Lagrange's differential equation, Hamilton's formalism, Legendre's transformation and Hamilton's equation of motion, Canonical or contrast transformation, advantages and examples, Condition for a transformation to be canonical, Mechanics of Rigid Bodies, and Theory of small oscillations.

Unit- II

 Nonlinear Dynamics: Flows on the line, Geometrical intuition, Fixed points, and stability, Local stability analysis, Bifurcations in one dimensional flow, Saddle node, Normal forms, Transcritical bifurcation, Pitchfork bifurcations, Imperfect bifurcation, Flows on the circle, Uniform oscillator, Non-uniform oscillator, Two dimensional flows, Linear systems, Definitions and examples, Classification of linear systems, Classical Perturbation methods in linear systems and nonlinear systems.

Unit-III

• Quantum Mechanics: Matrix Formulation of Quantum Mechanics, Schrodinger, Heisenberg and interaction pictures, Matrix theory of Harmonic oscillator, Rotation and angular momentum, Commutation relations, eigenvalue spectrum, angular momentum matrices of J+, J-, Jz, J^2 , Addition of angular momenta, Clebsch-Gordon coefficients.

Unit-IV

• Advanced Quantum Mechanics: Perturbation Theory, Time independent (degenerate and non-degenerate) perturbation theory and its applications, time dependent perturbation theory. Approximation Methods: Variational methods, WKB approximation, Scattering Theory, Partial wave analysis, Phase shifts, Applications of scattering and optical theorem, Born approximation and its applications.

Unit-V

• **Statistical Mechanics:** Ensemble theories, Density of states, Classical and quantum statistics, Bose and Fermi gas, Bose-Einstein Condensation.

Suggested Reading:

- 1. L.I. Schifff, Quantum Mechanics, McGraw-Hill, 2017.
- P. M. Mathews and K. Venkatesan, A Text Book of Quantum Mechanics, Tata McGraw Hill, 2010.
- 3. J. J. Sakurai, Modern Quantum Mechanics, Pearson, 2014.
- 4. N. Zettili, Quantum Mechanics: Concepts & Applications, Wiley India, 2017.
- 5. N C Rana and P S Joag: Classical Mechanics (Tata Mc Graw Hil, 1991)
- 6. H Goldstein: Classical Mechanics (Addition Wesley, 1980)
- 7. A Sommerfield: Mechanics (Academic Press, 1952)
- 8. I Percivel and D Richards: Introduction to Dynamics (Cambridge University Press)
- 9. Nonlinear dynamics and Chaos, by Steven Strogatz
- 10. Perturbation Methods by A. H. Nayfeh, Wiley-VCH.