

DOCTOR OF PHILOSOPHY

Physics (PhD)

Course Framework

Research Methodology

And

Research and Publication Ethics

Department of Studies in Physics

2026-27

Course Framework : Research Methodology

Course Title : Research Methodology

Course Category : Compulsory (Ph.D. Coursework)

Credits : 4

Course Structure : Theory

Course Learning Outcomes

Upon successful completion of the course, the research scholar will be able to:

1. **Integrate advanced mathematical, statistical, and physical concepts** to analyze complex research problems.
2. **Develop and validate theoretical and computational models** for experimental and physical systems.
3. **Critically evaluate scientific literature and experimental data** using rigorous quantitative methods.
4. **Apply interdisciplinary approaches** combining statistical methods, quantum theory, and electrodynamics.
5. **Demonstrate readiness for independent research** in core and applied areas of physics.

Pedagogy

1. Lecture-Based Conceptual Framework
2. Problem-Solving and Analytical Sessions
3. Computational and Data Analysis Training
4. Research-Oriented Assignments
5. Seminar Presentations
6. Self-Directed Learning
7. Case Studies and Applications
8. Interactive Discussions and Peer Learning
9. Continuous Assessment and Feedback
10. Research Integration

Assessment

Assessment shall include continuous evaluation and course-end examination as prescribed by the concerned Board of Studies in accordance with University norms.

Course Content

Unit 1 Description and Modeling of Data

Description of Data: Introduction; Moments of a distribution: Mean; Variance; Skewness, Standard deviation; Efficient search for the median; Estimation of the mode for continuous data; Two distributions: Student's t-test, F-test, Chi-square test; Linear correlation; Nonparametric or Rank correlation; Smoothing of data. Definition and sources of error. Propagation of errors.

Modeling of data: Introduction; Least-squares as a maximum likelihood estimator; Fitting data to a straight line; General linear least squares; Nonlinear models; Confidence limits; Robust estimation.

Reference Books:

1. Schaum's Outline of statistics, Spiegel M.R. and Stephens L.J., McGraw Hill, USA, 1998.
2. An introduction to numerical analysis, Atkinson K.E., John Wiley and Sons, 1989; pp.17-34.
3. Numerical recipes in C, Press W.H., Flannery B.T., Teukolsky S.A., and Vetterling W.T., Cambridge University Press, Cambridge, 1988; Chapter 14.

Unit 2 Statistical Mechanics

Partition function (Chapter 2); Partition function of a gas of non-interacting point particles, Average energy and entropy of this system (Chapter 3); Partition function of a gas of non-interacting particles with structure like molecule, average energy, classical and quantum mechanical results (Chapter 4); Partition function of a harmonic oscillator, average energy, classical and quantum mechanical results (Chapter 5).

Reference Books:

1. Statistical mechanics: A survival guide, Glazer A.M. and Wark J.S., Oxford University Press, 2001.
2. Statistical mechanics, Huang K., John Wiley and Sons, USA, 1963; Chapter 15.
3. Statistical mechanics, 2nd Edition, Agarwal B.K., New Age International (Pvt.) Limited, 2005.

Unit 3 Quantum Mechanics

Perturbation Theory for Bound States, Atomic Fine Structure. Time-Dependent Perturbation Theory, Fermi's Golden Rule, Radiative Identical Particles, Creation/Annihilation, State Vectors. Many Body Applications: Perturbation Theory and Quantum Statistics. Quantized Electromagnetic Fields, Photons. Relativistic quantum mechanics for electrons, Dirac Equation.

Reference Books:

1. Quantum mechanics, 3rd Edition, Merzbacher E., John Wiley, USA, 1998; Chapters 18, 19, 21-24.

Unit 4: Classical Electrodynamics

Boundary Value problems in electrostatics- Uniqueness theorem - Method of Electrical images- Grounded conducting sphere in uniform electric field. Magnetization- Magnetic susceptibility and permeability- boundary conditions- Uniformly magnetized sphere in an external magnetic field. Guided waves- TE waves in a rectangular wave guide- coaxial transmission line. Dispersion- in gases, liquids and solids. Electric and magnetic multipoles- Multipole expansion of electromagnetic fields. Multipole transitions. Covariant formulation of electrodynamics- Electromagnetic field tensor. Lagrangean formulation of the motion of a charged particle in an electromagnetic field.

Reference Books:

1. Classical Electrodynamics, 3rd Edition, Jackson J.D., John Wiley and Sons, USA, 1998; Chapters 8& 9
2. Introduction to Electrodynamics, 3rd Edition Griffiths D.J., Prentice-Hall of India 1999; Chapters 9
3. Electromagnetics, Laud B.B., Wiley Eastern Limited 1983; Chapters 3, 4 and 11.

Additional Learning Resources

A. Core Textbooks

1. Spiegel, M.R. and Stephens, L.J., *Schaum's Outline of Statistics*, McGraw-Hill, New York, USA, **1998**.
2. Atkinson, K.E., *An Introduction to Numerical Analysis*, John Wiley & Sons, New York, USA, **1989**.
3. Press, W.H., Flannery, B.P., Teukolsky, S.A., and Vetterling, W.T., *Numerical Recipes in C: The Art of Scientific Computing*, Cambridge University Press, Cambridge, UK, **1988**.
4. Glazer, A.M. and Wark, J.S., *Statistical Mechanics: A Survival Guide*, Oxford University Press, Oxford, UK, **2001**.
5. Huang, K., *Statistical Mechanics*, John Wiley & Sons, New York, USA, **1963**.
6. Agarwal, B.K., *Statistical Mechanics*, 2nd Edition, New Age International Publishers, New Delhi, India, **2005**.
7. Merzbacher, E., *Quantum Mechanics*, 3rd Edition, John Wiley & Sons, New York, USA, **1998**.
8. Jackson, J.D., *Classical Electrodynamics*, 3rd Edition, John Wiley & Sons, New York, USA, **1998**.
9. Griffiths, D.J., *Introduction to Electrodynamics*, 3rd Edition, Prentice Hall of India, New Delhi, India, **1999**.
10. Laud, B.B., *Electromagnetics*, Wiley Eastern Limited, New Delhi, India, **1983**.

B. Additional Reference Books

11. Bevington, P.R. and Robinson, D.K., *Data Reduction and Error Analysis for the Physical Sciences*, McGraw-Hill, New York, USA, **2003**.
12. Taylor, J.R., *An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements*, University Science Books, California, USA, **1997**.
13. Reif, F., *Fundamentals of Statistical and Thermal Physics*, McGraw-Hill, New York, USA, **1965**.

14. Landau, L.D. and Lifshitz, E.M., *Statistical Physics*, 3rd Edition, Butterworth-Heinemann, Oxford, UK, **1980**.
15. Kardar, M., *Statistical Physics of Particles*, Cambridge University Press, Cambridge, UK, **2007**.
16. Sakurai, J.J. and Napolitano, J., *Modern Quantum Mechanics*, 2nd Edition, Cambridge University Press, Cambridge, UK, **2011**.
17. Dirac, P.A.M., *The Principles of Quantum Mechanics*, 4th Edition, Oxford University Press, Oxford, UK, **1958**.
18. Shankar, R., *Principles of Quantum Mechanics*, 2nd Edition, Springer, New York, USA, **2012**.
19. Cohen-Tannoudji, C., Diu, B. and Laloë, F., *Quantum Mechanics*, Wiley-VCH, **1977**.
20. Purcell, E.M. and Morin, D.J., *Electricity and Magnetism*, 3rd Edition, Cambridge University Press, Cambridge, UK, **2013**.
21. Arfken, G.B., Weber, H.J. and Harris, F.E., *Mathematical Methods for Physicists*, 7th Edition, Academic Press, USA, **2013**.
22. Boas, M.L., *Mathematical Methods in the Physical Sciences*, 3rd Edition, John Wiley & Sons, USA, **2006**.

C. Online Learning Resources

1. NPTEL (National Programme on Technology Enhanced Learning), Government of India – Online Courses in Physics and Statistics, <https://nptel.ac.in>
2. MIT OpenCourseWare (OCW) – Physics Courses, Massachusetts Institute of Technology, <https://ocw.mit.edu>
3. Tong, D., *Statistical Physics Lecture Notes*, University of Cambridge, **2012**.
4. arXiv.org – Open-access repository for physics research papers, Cornell University, <https://arxiv.org>
5. Feynman, R.P., Leighton, R.B., and Sands, M., *The Feynman Lectures on Physics*, California Institute of Technology, **1964 (online edition available)**

D. Computational Tools

1. Python (NumPy, SciPy, Matplotlib), Python Software Foundation, **2000–present**
2. MATLAB, MathWorks Inc., **1984–present**
3. Mathematica, Wolfram Research, **1988–present**

Course Framework: Research and Publication Ethics

Course Title : Research and Publication Ethics

Course Category : Compulsory (Ph.D. Coursework)

Credits : 2

Course Structure : Theory

Course Learning Outcomes

On completion of the course, the research scholar shall be able to:

1. Explain the principles of research integrity and ethical scholarly conduct.
2. Identify various forms of research and publication misconduct.
3. Apply authorship norms, citation ethics, and conflict-of-interest guidelines.
4. Use plagiarism detection tools and journal evaluation tools responsibly.
5. Interpret research metrics with due caution and responsibility.

Pedagogy

1. Lectures
2. Guided discussions
3. Hands-on sessions
4. Case analysis
5. Assignments/seminars

Assessment

Assessment shall include continuous evaluation and course-end examination as prescribed by the concerned Board of Studies in accordance with University norms.

Course Content

Unit I: Philosophy, Ethics and Scientific Conduct

Introduction to Philosophy: definition, nature, scope, concepts and branches, Ethics: definition and moral reasoning, Ethics in science and research, Intellectual honesty and research integrity, Research misconducts: Fabrication, falsification and plagiarism (FFP), Redundant publication (duplicate/overlapping publications, salami slicing), Selective reporting and misrepresentation of data

Unit II: Publication Ethics and Misconduct

Meaning and importance of publication ethics, Best practice guidelines (COPE, WAME, etc.), Authorship and contributorship, Conflicts of interest, Publication misconducts: definition, causes, consequences and types. , Violation of publication ethics, Retraction policies and correction mechanisms in scholarly publishing, Identification of publication misconduct, Complaints and appeals, Predatory journals and publishers
Subject-specific ethical issues and case studies

Unit III: Open Access and Scholarly Communication Tools

Open Access Publishing Models and Supporting Platforms: Gold, Green, Hybrid models; SHERPA/RoMEO, DOAJ, arXiv, SSRN, and self-archiving practices. Journal finder and journal suggestion tools

Tools for Identifying and Verifying Predatory Journals: Cabells Predatory Reports, Beall's List, and whitelist/indexing platforms such as Directory of Open Access Journals (DOAJ), Scopus Source List, and Journal Citation Reports (JCR).

Plagiarism detection software: tools, limitations, and responsible interpretation of similarity reports, Good citation practices and responsible scholarly writing

Unit IV: Databases and Research Metrics

Databases: Indexing databases, Citation databases (Web of Science, Scopus, etc.)

Research Metrics: Journal Impact Factor and Journal Citation Reports, SNIP, SJR, IPP, CiteScore, Author metrics: h-index, g-index, i10-index, Introduction to altmetrics, Responsible use and limitations of metrics

Learning Resources

1. Amos, K. A. (2014). The ethics of scholarly publishing: Exploring differences in plagiarism and duplicate publication across nations. *Journal of the Medical Library Association*, **102**(2), 87–91. <https://doi.org/10.3163/1536-5050.102.2.005>
2. Basu, D., Chakraborty, S., & Sinha, A. (2021). *Research and publication ethics: A textbook*. Concept Publishing Company Pvt. Ltd.
3. Bos, J., Hoeneveld, F., Steenbergen, N. V., Abma, R., Meijl, T. V., & Lepianka, D. (2020). *Research ethics for students in the social sciences*. Springer. <https://doi.org/10.1007/978-3-030-48415-6>

4. Chowdhary, N., & Hussain, S. (Eds.). (2021). *Handbook of research and publication ethics*. Bharti Publications.
5. Committee on Publication Ethics (COPE). (2022, September 15). *Principles of transparency and best practice in scholarly publishing*. <https://publicationethics.org/guidance/guideline/principles-transparency-and-best-practice-scholarly-publishing>
6. Derricourt, R. (1996). *An author's guide to scholarly publishing*. Princeton University Press.
7. Elsevier. (2012). *Ethics in research & publication*. https://www.publishingcampus.elsevier.com/websites/elsevier_publishingcampus/files/Guides/Brochure_Ethics_2_web.pdf
8. Horner, J., & Minifie, F. D. (2011). Research ethics III: Publication practices and authorship, conflicts of interest, and research misconduct. *Journal of Speech, Language, and Hearing Research*, *54*(1), 346–362. [https://doi.org/10.1044/1092-4388\(2010/09-0263\)](https://doi.org/10.1044/1092-4388(2010/09-0263))
9. Iltis, A. S., & MacKay, D. (Eds.). (2024). *The Oxford handbook of research ethics*. Oxford University Press.
10. International Committee of Medical Journal Editors (ICMJE). (2022). *Recommendations for the conduct, reporting, editing, and publication of scholarly work in medical journals*. <http://www.icmje.org/icmje-recommendations.pdf>
11. Oliver, P. (2010). *The student's guide to research ethics*. McGraw-Hill Education.
12. Posner, R. A. (2007). *The little book of plagiarism* (1st ed.). Pantheon Books.
13. Ray, P. P. (2022). *A guide to research and publication ethics: A textbook as per UGC guidelines for UG, PG, MPhil and PhD*. New Delhi Publishers.
14. Roig, M. (2006). *Avoiding plagiarism, self-plagiarism, and other questionable writing practices: A guide to ethical writing*. Office of Research Integrity. <https://ori.hhs.gov/sites/default/files/plagiarism.pdf>
15. Sheeba, P. S. (2024). *Research and publication ethics: A comprehensive guide to ethical research practices*. Notion Press.
16. Singh, U. P., Ahlawat, S., & Sharma, S. (2023). *Research and publication ethics*. Sultan Chand & Sons.
17. Tolich, M., & Iphofen, R. (Eds.). (2018). *The SAGE handbook of qualitative research ethics*. SAGE Publications.
18. Wager, E., & Kleinert, S. (2014). Responsible research publication: International standards for authors. In A. Mayer & N. Steneck (Eds.), *Promoting research integrity in a global environment* (pp. 309–316). World Scientific.