B.Sc. (Honours) Physics

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 11
RESEARCH METHODOLOGY

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Research Methodology DSE 11	4	3	0	1	Basic ICT related skills

COURSE OBJECTIVES

This course has been designed to explore the basic dimensions of research and to impart quantitative and qualitative knowledge for conducting meaningful research. Starting from the philosophy of research, through awareness about the publication ethics and misconducts, this course covers all the methodological and conceptual issues required for a successful conduct of research. It gives an overview of research techniques, data management and analysis, and commonly used statistical methods in physical sciences.

LEARNING OUTCOMES

After successful completion of this course, students will be trained in the following.

- Skills to review literature and frame research problem.
- Comprehend the relevance of the tools for data collection and analysis.
- Writing a scientific report/research proposal.
- Software tools for research in physical sciences.
- Research integrity and publication ethics.
- Importance of intellectual property rights.
- Role of funding agencies in research.

SYLLABUS OF DSE 11
THEORY COMPONENTS
(Hours: 45)

Unit I **(6 Hours)**

Introduction to research methodology

Brief history of scientific method and research, role and objectives of research, basic tenets of qualitative research; research problem and review of literature: identifying a research problem (philosophy and meaning of research, identification and definition of research problem, formulation of research problem, sources of prejudice and bias); literature survey

(open-source and paid tools for keeping track of the literature)

Unit II **(15 Hours)**

Data collection, analysis and interpretation

Methods of data collection: survey, interview, observation, experimentation and case study; Descriptive statistics: Measures of central tendency (mean, median, mode) and dispersion (range, standard deviation).

Inferential statistics: Hypothesis testing, Z test, T test; regression analysis (basic concepts of multiple linear regression analysis and theory of attributes).

Curve fitting using linear and nonlinear regression (parameter space, gradient search method and Marquardt method).

Role of simulation, calibration methods, error analysis, and background handling in experimental design.

Unit III **(7 Hours)**

Journals, Database and Research Metrics

Journals: Free, open source and paid journals, concept of peer reviewed journals, predatory and fake journals.

Databases: Indexing databases; citation databases (Web of science, Scopus); experimental physics databases (astrophysics (ADS, NED, SIMBAD, VizieR), biophysics (PubMed), particle physics (INSPIRE, CDS), condensed matter physics (X-ray database))

Research Metrics: Journal impact factor, SNIP, SJR, IPP, cite score; metrics (h-index, g index, i10 index, altmetrics), variations in research metrics across various disciplines, other limitations of the research metrics and impact factors

Unit IV **(8 Hours)**

Scientific Conduct and Publication Ethics

Current understanding of ethics; intellectual honesty and research integrity; communicating errors (erratum, correction and withdrawal); records and logs (maintaining records of samples, raw data, experimental protocols, observation logs, analysis calculations, and codes); scientific publication misconducts: plagiarism (concept, importance, methods and ways to detect and avoid plagiarism) and redundant publications (salami slicing, duplicate and overlapping publications, selective reporting and misrepresentation of data); environmental and other clearances (waste management, disposal of hazardous waste).

COPE guidelines on best practices in publication ethics

Unit V **(5 Hours)**

Scientific Writing and Software Tools

Writing a research paper and report: introduction, motivation, scientific problem, its methodology, any experimental set up, data analysis, discussion of results, conclusions Referencing formats (APA, MLA) and bibliography management

Graphical software (open source, magic plot, gnu plot, origin); presentation tools (beamer)

Unit VI **(4 Hours)**

Intellectual Property Right and Research Funding

Basic concepts and types of intellectual property (patent, copyright and trademark)
Role of funding agencies in research, overview of various funding agencies (DST-SERB, UGC, CSIR, BRNS, DRDO), national and international research project grants and fellowships

PRACTICAL COMPONENT: RESEARCH METHODOLOGY

(Hours: 30)

Students should perform at least 6 experiments from the following list, such that all the units mentioned below are covered.

Unit 1:

1. Identify a research problem, write its brief summary and make a corresponding flow chart
2. Identify a survey-based research problem in physics and create a questionnaire to collect data to perform meaningful research.
3. Write a literature review for a research problem.
4. Create a list of research topics (at least three) and read at least one research paper in each topic.

Unit 2:

1. Attend a research seminar and write a brief summary in 1000 words. Check the extent of plagiarism in this summary by using on-line plagiarism detection tools
2. Read a research paper based on the use of statistics in experimental physics and summarise its importance.
3. Collect publicly available experimental physics data. Identify the independent, dependent and control variables. Fit at least two mathematical models that can describe the data and compare their statistical significance.

Unit 3:

1. Review any three research papers.
    a. List the major strengths and weakness of all of them.
    b. For any one of these, create a referee report assuming you are a reviewer of the paper. Also draft a response to the referee's report assuming you are the author.
2. Review any research paper. Rewrite it as if the work has been done by you for the first time. Use two different referencing and bibliography styles

Unit 4:

1. Take data from any publicly available experimental physics database. Use Microsoft Office tools (such as chart/bar diagrams, equation editor etc. in Word, PowerPoint or Excel) to present, plot and infer relevant information from the data.
2. Write a scientific synopsis of a research paper using LaTeX.
3. Create a presentation using LaTeX and Beamer on any research topic
4. Select a funding agency and any two schemes or fellowships offered by them.

Make a report (using LaTeX) describing the objectives, areas of research support and various components of grants offered by them.

REFERENCES

Essential Readings

1) Management Research Methodology, K. N. Krishnaswamy, A. I. Sivakumar, M. Mathirajan, 2006, Pearson Education, New Delhi.
2) Research Methodology, Methods and Techniques, C. R. Kothari, 2nd edition, 2008, New Age International Publication.
3) Research Methodology, A step by step guide for beginners, R. Kumar, 6th edition, 2009, Pearson Education
4) Data reduction and error analysis for the physical sciences, P. R. Bevington and D. K. Robinson, 3rd edition, McGraw-Hill
5) Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets, C. J. Holland, 2007, Entrepreneur Press

Additional Readings

1) Research Methods, R. Ahuja, 2001, Rawat Publications, New Delhi.
2) Research design: Qualitative, quantitative, and mixed methods approaches, J. W. Creswell, and J. D. Creswell, 2017, Sage Publications.
3) Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, A. R. Miller and
M. H. Davis, 2000, West Group Publishers