Course Structure & Syllabi

for Coursework in

Doctor of Philosophy (Ph.D.) Coursework

in Computer Science

(Applicable for the students admitted w.e.f. academic year 2024-25)

Department of Computer Science
Faculty of Mathematical Sciences
University of Delhi, Delhi-110007.

List of Courses and Distribution of Credits

SEMESTER I		
Course Code	**Course Title**	**Credits**
RCS101	Research Methodology	04
RCS102	Research and Publication Ethics	02
RCS103	Essentials of Computing Research	04
RCS11X	Major Elective I	04
	Total	**14**

RCS101	Research Methodology	L	T	P
		3	1	0

Learning Objectives: This course provides an in-depth exploration of the philosophical underpinnings, methodologies, and techniques essential for conducting research in computer science. It covers topics such as formulating research questions, designing research projects, collecting and analyzing data (including primary and secondary data), interpreting and presenting findings effectively, and documenting research through well-structured and well-written papers and theses.

Learning outcomes: Upon completion of this course, students will be able to:

- Design research with clear objectives, methodology, and scope.
- Select and implement appropriate data collection methods.
- Employ relevant sampling techniques to ensure data validity.
- Analyze and interpret research data effectively.
- Document research findings effectively in the form of a paper or thesis.

Syllabus:

Introduction: Evolution of Scientific Inquiry, Scientific Research: Definition, Characteristics, types, need of research. Formulating a research question: Identification of the problem, Assessing the status of the problem, Literature Review and Identifying Research Gaps, Sources and strategies for literature review, Critical analysis of research articles. Research Design: Exploratory, descriptive, and explanatory research designs. Qualitative, quantitative, and mixed-methods approaches. Choosing an appropriate design, Research Proposal Writing.

Data Collection: Primary and Secondary data, Structured and unstructured data, Types of Data – Categorical, nominal & Ordinal, Concept of dependent and independent variable, Methods of Collecting Data: Observation, field investigations, Direct studies – Reports, Records or Experimental observations. Sampling methods.

Descriptive statistics: Measures of central tendency and variability, representation of data: stem and leaf diagram, histogram, boxplot, and ogive; bar diagram and its variations, Pie charts; probability distributions: discrete and continuous, joint and conditional probability; theory of attributes: coefficient of association and coefficient of colligation.

Statistical Inference: Parameter and statistic, sampling distributions, confidence intervals and margin of error, developing hypotheses, hypothesis testing; Non-parametric tests: Student t-test, chi-square test, Mann-Whitney U test, Kruskal-Wallis test, Spearman's rank correlation coefficient.

Regression and Classification: Correlation: measure and significance, simple linear regression, multiple linear regression, one-way classification, analysis of variance, two-way classification, analysis of covariance, curvilinear regression, factorial experiments.

Data Analysis, Visualization and Interpretation: Quantitative and Qualitative data analysis, Qualitative data analysis- Thematic analysis, grounded theory, narrative analysis. Data visualization: Effective presentation of findings using charts, graphs, tables, plots etc. Drawing conclusions from data: Interpreting findings in the context of the research question and existing literature. Validation of results.

REFERENCES:

1. C.R. Kothari, and G.Garg. Research Methodology: Methods and Techniques. New Age International Publishers, 2019.
2. R. Panneerselvam. Research methodology. PHI Learning Pvt. Ltd., 2014.
3. R. Kumar. Research methodology: A step-by-step guide for beginners. Pearson Education, 2010.
4. Relevant study material from ACM, IEEE, Elsevier, Springer

RCS102	Research and Publication Ethics	L	T	P
		2	0	0

Philosophy and Ethics: Introduction to Philosophy- Definitions, nature and scope, concepts, branches; Ethics- definition, moral philosophy, nature of moral judgements and reactions.

Scientific Conduct: Ethics with respect to science and research, Intellectual honesty and research integrity; Scientific misconducts- Falsification, fabrication, and Plagiuarism; Redundant Publications- duplicate and overlapping publications, salami slicing; Selective reporting and misrepresentation of data.

Publication Ethics: Definition, Introduction and Importance; Best Practices/ standards setting initiatives and guidelines- COPE, WME etc.; Conflicts of Interest; Publication misconduct- Definition, concept, problems that lead to unethical behavior and vice versa; types; Violation pf publication ethics, authorship and contributorship; Identification of publication misconduct, Complaints and appeals; Predatory publishers and journals.

Open Access Publishing: Open access publication and initiatives, SHERPA, RoMEO Online resource to check publication copyright and self-archiving policies; Software tools to identify predatory publications, Journal finder/ journal suggestion tools; Pre-print archives and Institutional repositories.

Publication Misconduct: Subject specific ethical issues, Falsification, fabrication, and Plagiuarism, authorship; Conflicts of interests; Complaints and appeals; Examples from India and abroad; Use of plagiarism software like Turnitin, Urkund, Drillbit, and other open software tools.

Databases and Research Metrics: Indexing databases, Citation databases- Web of Science, Scopus etc.; Impact factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score; Metrics- h index, g index, i10-index, altmetrics.

REFERENCES:

1. Bird, A. (2006). Philosophy of Science, Routledge
2. Maclntyre, Alasdair (1967) A Short History of Ethics, London
3. P. Chaddah (2018) Ethics in Competitive Research: Do not get sooped: do not get plagiarized, ISBN: 978-9387480865
4. 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.
5. 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.cfm
6. Beall, J. (2012). Predatory publishers are corrupting open access. Nature, 489(7415), 179-179. https://doi.org/10.1038/489179a
7. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance (2019), ISBN: 978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics Book.pdf

RCS103	Essentials of Computing Research	L	T	P
		3	1	0

LEARNING OBJECTIVES: The objective of this course is to provide a comprehensive understanding of the foundational and advanced concepts in computer science, spanning programming paradigms, computational complexity, performance measurement and evaluation, and the emerging paradigms of artificial intelligence (AI), Machine Learning (ML) and Deep Learning (DL). The objective is to equip students with a robust theoretical knowledge base, practical skills, and the ability to apply these concepts to solve complex problems in computer science.

LEARNING OUTCOMES: Upon completion of this course, students will be able to:

- develop critical thinking, analytical skills, and innovative approaches to research
- understand and apply programming paradigms
- analyze the computational complexity of algorithms
- conduct performance analysis of developed algorithms
- develop artificial intelligence and machine learning solutions

SYLLABUS:

Revisiting Programming Paradigms and Concepts: Imperative paradigm: Conditional, and iteration blocks, Functions, Data Types. Recursion, Block Structure, Abstract Data Types, Local-global Variables, Static-dynamic Types, Control Flow Diagrams, Syntax Tree, sentinel. Functional Programming – Functional Style, Immutability, List and Recursion, Higher-order Functions, Lists and Recursion, Constraint Programming. Object-oriented (OO) Programming – Object-oriented Design Principles, Encapsulation, Inheritance, and Polymorphism. Concurrent Programming Paradigm: concurrency vs parallelism, processes, threads, synchronization, and deadlock.

Computational Complexity: Quantification of resources used by algorithms- Time and Space; Complexity Measures (Big O, Big Ω, and Big Θ notations) and Classes (P, NP, NP-complete, and NP-hard); Deterministic and Non-deterministic algorithms, The Class P and Set of Tractable Computational problems, Approximation algorithms.

Performance Evaluation: Notion of Precision and Recall, Confusion Matrix, E and F measure, Probabilistic Mutual Information (PMI), Normalized Discounted Cumulative gain (NDGC), Rank Correlation- Spearman Coefficient and Kendall Tau, Distance Measures, Similarity Measures, Rand Index, Data Annotation, Inter-annotator agreement measures, Balanced and Imbalanced Datasets, Cross-folding, Overfitting and Underfitting.

AI-ML-DL: Introduction to Artificial Intelligence, Machine Learning and Deep Learning, AI Definitions and approaches, AI applications, Basics of Machine Learning, Supervised Learning Algorithms, Unsupervised Learning Algorithms, Introduction to Artificial Neural Networks, Non-linearities, ANN Architectures, Introduction to Deep Learning Foundations, Convolutional Neural Networks, Recurrent Neural Networks, Long Short-Term Memory Networks, Transformer-based models, Hyperparameter tuning, Pre-training and Pretrained Models, Continual Training.

REFERENCES:

1. M.A. Weiss; Data Structures and Algorithm Analysis in ADA; Benjamin Cummings Publishing; 1993
2. P.E. Dunne; Computability Theory - concepts and applications; Ellis Horwood; 1991

RCS11X	Major Elective I	L	T	P
		3	1	0

A candidate will choose an elective course from the set of Masters or higher-level courses offered by the department as per the recommendations of the Research Advisory Committee. The list may be updated by the department on regular intervals. In specific cases, where a relevant course is not being offered by the department, but is available in another department of the faculty or on SWAYAM platform, the candidate may opt such a course as elective on the recommendations of the Research Advisory Committee and approval of the DRC. However, in such cases the department may conduct additional evaluation for award of marks, if required.