CENTRAL UNIVERSITY OF HARYANA

(Established under the Central Universities Act, 2009)

(NAAC Accredited 'A' Grade)

CBCS Based

Curriculum and Syllabi
of
Ph.D. (Computer Science) Course Work
(w.e.f. July, 2025 onwards)

DEPARTMENT OF COMPUTER SCIENCE &
INFORMATION TECHNOLOGY

SCHOOL OF BASIC SCIENCES

CENTRAL UNIVERSITY OF HARYANA

SCHOOL OF BASIC SCIENCES

DEPARTMENT OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

Course Structure and Curriculum for Course Work for Ph.D. (Computer Science) Degree

Sr. No		Course Name	Course Code	Course Type	Credit
1.	Research Methodology		SBS CSIT 030101 C 5016	Core	6
Compulsory course as per UGC Guidelines (Offered by Central Library)					
2.	Research and Publication Ethics		CPE-RPE	Core	2
Any one course from					
3.	Internet of Things		SBS CSIT 030102 E 5016	Elective	6
4.	Data Warehouse and Mining		SBS CSIT 030103 E 5016	Elective	6
5.	Data Science		SBS CSIT 030104 E 5016	Elective	6
6	Quantum Computing		SBS CSIT 030105 E 5016	Elective	6
7	Ad-Hoc & Sensor Networks		SBS CSIT 030106 E 5016	Elective	6
8	Artificial Intelligence and Machine Learning		SBS CSIT 030107 E 5016	Elective	6
				Total Credits	**14**

Eligibility: PG Degree in computer science / computer science and application / information technology / computer science and engineering OR specialization in computer / information technology domain.

* *Selection criteria, eligibility, examination, reservation policy, etc. as per UGC guidelines / CU Haryana PhD ordinance.*

Central University of Haryana
Department of Computer Science and Information Technology

Course Type	:	**Core**
Course Name	:	**Research Methodology**
Course Code	:	**SBS CSIT 030101 C 5016**
Contact Hrs. per week	:	6
Credit	:	6

Course Objective and Learning Outcomes:
The guiding philosophy of knowledge creation and dissemination will be discussed in this course. The idea about various approaches to research, data collection, analysis, and inference will be taught. Principles of formulating research problems, designing experiments, and documentation will form a major part of the course. Specific objectives and techniques of chemical sciences research will also be presented. At the end of the course the students are expected to identify, design, and plan research problems, prepare research proposals and contemplate publications and reports when presented with data.

UNIT I: METHODS AND TYPES OF RESEARCH
Research methods vs Methodology. Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical. Research proposals-design and components.

UNIT II: LITERATURE REVIEW
Defining and formulating the research problem - Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem – Literature review – Primary and secondary sources – reviews, treatise, monographs-patents – web as a source – searching the web - Critical literature review – Identifying gap areas fromliterature review - Development of working hypothesis.

UNIT-III: SCIENTIFIC SOFTWARE IN RESEARCH DESIGN AND METHODS AS APPLIED
Data Analysis using Tools like MS Excel, Tableau and SQL, etc.
Digital Methods and Web Search: Internal basics, Internet protocols, pre-requisites, search engines – Sco pus, Google scholar, Scifinder, research gate; using

advanced search techniques, web resources, e-journals, e-books, journal access, subscribingTOC alerts, hot articles, citation index – h-index and i-index; Impact factor.

UNIT-V: REPORTING, DOCUMENTATION, AND PRESENTATION
Scientific Document: Organization and writing of research papers, short communications, review articles, monographs, technical and survey reports, authored books, and edited books and

dissertations.

Writing of Thesis: Format of a thesis: Review of literature, formulation, writing methods, results, preparation of tables, figures, writing discussion, summary and conclusion, synopsis, references citing and listing, bibliography, acknowledgment, avoiding plagiarism, Oralpresentations-visual aids.

Suggested Readings

1. A. Fink, Conducting Research Literature Reviews: From the Internet to Paper, Sage Publications, 2009.
2. M. Graziano, A.M. Anthony and M. L. Raulin, Research Methods: A Process of Inquiry, Allyn and Bacon., 2009.
3. W. M. K. Trochim, Research Methods: the concise knowledge base, Atomic Dog Publishing, 2005.
4. P. D. Leedy and J. E. Ormrod, Practical Research: Planning and Design, Prentice Hall, 2004.
5. B. L. Garg, R. Karadia, F. Agarwal and U. K. Agarwal, An introduction to Research Methodology, RBSA Publishers, 2002.
6. R. A. Day, How to Write and Publish a Scientific Paper, Cambridge University Press, 1992.
7. C. R. Kothari, Research Methodology: Methods and Techniques, New Age International, 1990.
8. S. M. Coley and C. A. Scheinberg, Proposal Writing, Sage Publications, 1990.

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Course Type	:	**Core**
Course Name	:	**Research and Publication Ethics**
Course Code	:	**CPE-RPE**
Credits	:	**2**

Theory

RPE 01: Philosophy and Ethics (3 hrs.)

1. Introduction to philosophy: definition, nature and scope, concept, branches
2. Ethics: definition, moral philosophy, nature of moral judgment, and reactions

RPE 02: Scientific Conduct (5 hrs.)

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data

RPE 03: Publication Ethics (7 hrs.)

1. Publication ethics: definition, introduction, and importance
2. Best practices / standards-setting initiatives and guidance: COPE, WAME, etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types
5. Violation of publication ethics, authorship, and contributorship
6. Identification of publication misconduct, complaints, and appeals
7. Predatory publishers and journals

Practice

RPE 04: Open Access Publishing (4 hrs.)

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

RPE 05: Publication Misconduct (4 hrs.)

A. Group Discussion (2 hrs.)

1. Subject-specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools (2 hrs.)

1. Use of plagiarism software like Turnitin, Urkund, and other open-source software tools

RPE 06: Databases and Research Metrics (7 hrs.)

A. Databases (4 hrs,)

1. Indexing databases Research Metrics
2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics (3 hrs.)

1. Impact Factor of the journal as per Journal Citation Report, SNIP, SJR, IIP, Cite Score
2. Metrics: h index, g index, i10 index, metrics

Suggested Readings:

1. Bird, A. (2006). *Philosophy of Science.* Routledge
2. MacIntyre, Alasdair (1967) *A Short History of Ethics.* London
3. P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; 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 and why is it important. National Institute of Environmental Health Sciences, 1-10. Retrieved from https://www.neihs.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.
8. Vishal Goyal, G S Batra "Research and Publication Ethics" DPS Publication House.

Central University of Haryana
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Course Type	:	**Elective**
Course Title	:	**Internet of Things**
Course Code	:	**SBS CSIT 030102 E 5016**
Contact Hrs. per week	:	**6**
Credit	:	**6**

Course Objective and Learning Outcomes:
Students will understand the concepts of Internet of Things and can able to build IoT applications. Understand the concepts of Internet of Things, analyze basic protocols in wireless sensor networks, Design IoT applications in different domains and be able to analyze their performance.

UNIT I
Introduction to IoT: Sensing, Actuation, Networking basics, Communication Protocols, Sensor Networks, Machine-to-Machine Communications, IoT Definition, Characteristics. IoT Functional Blocks, Physical design of IoT, Logical design of IoT, Communication models & APIs. IoT Protocols and Their Comparison (MQTT, CoAP, HTTP)

UNIT II
M2M to IoT-The Vision-Introduction, From M2M to IoT, M2M towards IoT-the global context, A use case example, Differing Characteristics. Definitions, M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT. M2M vs IoT. Energy-Efficient IoT Devices

UNIT III
An Architectural Overview–Building architecture, Main design principles and needed capabilities, An IoT architecture outline, and standards considerations. Reference Architecture and Reference Model of IoT. IoT and Machine Learning for Predictive Maintenance. Edge Computing in IoT.

UNIT IV
IoT Reference Architecture- Getting Familiar with IoT Architecture, Various architectural views of IoT such as Functional, Information, Operational, and Deployment. Constraints affecting design in IoT world-Introduction, Technical design Constraints.

UNIT V
Domain-specific applications of IoT: Home automation, Industry applications, Surveillance applications, Other IoT application.
Developing IoT solutions: Introduction to Python, Introduction to different IoT tools, Introduction to Arduino and Raspberry Pi, Data Aggregation for the IoT in Smart Cities, Privacy and Security Issues in IoT.

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Suggested Readings

1. Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-onApproach)", 1E, VPT
2. Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand, StamatisKarnouskos, David Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", 1st Edition, Academic Press
3. Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1st Edition, Apress Publications
4. CunoPfister, Getting Started with the Internet of Things, O"Reilly.
5. Olivier Hersent, David Boswarthick, Omar Elloumi "The Internet of Things: Key Applications and Protocols" 2nd Edition. ISBN: 978-1-119-99435-0.

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Course Type	:	**Elective**
Course Title	:	**Data Warehouse and Mining**
Course Code	:	**SBS CSIT 030103 E 5016**
Contact Hrs. per week	:	6
Credit	:	**6**

Course Objective and Learning Outcomes:
This course gives an introduction to methods and theory for the development of data warehouses and data analysis using data mining. Data quality and methods and techniques for preprocessing of data. Modeling and design of data warehouses. Algorithms for classification, clustering, and association rule analysis. Practical use of software for data analysis.

UNIT I
Introduction: Fundamentals of data mining, Data Mining Functionalities, Classification of Data Mining Systems, Data Mining Task Primitives, Integration of a Data Mining System with a Database or a Data Warehouse System, Major issues in Data Mining. Data Preprocessing: Need for Preprocessing; the Data, Data Cleaning, Data Integration and Transformation, Data Reduction, Discretization, and Concept Hierarchy Generation.

UNIT II
Data Warehouse and OLAP Technology for Data Mining: Data Warehouse, Multidimensional Data Model, Data Warehouse Architecture, Data Warehouse Implementation, Further Development of Data Cube Technology, From Data Warehousing to Data Mining Different types of Cubes and Data Generalization: Further Development of Data Cube and OLAP Technology, Attribute-Oriented Induction.

UNIT III
Mining Frequent Patterns, Associations, and Correlations: Basic Concepts, Efficient and Scalable Frequent Itemset Mining Methods, Mining various kinds of Association Rules, From Association Mining to Correlation Analysis, Constraint-Based Association Mining. Classification and Prediction: Issues Regarding Classification and Prediction, Classification by Decision Tree Induction, Bayesian Classification, Rule-Based Classification, Classification by Backpropagation, Support Vector Machines, Associative Classification, Lazy Learners, Other Classification Methods, Prediction, Accuracy and Error measures, Evaluating the accuracy of a Classifier or a Predictor, Ensemble Methods

UNIT IV

Cluster Analysis Introduction: Types of Data in Cluster Analysis, A Categorization of Major Clustering Methods, Partitioning Methods, Hierarchical Methods, Density-Based Methods, GridBased Methods, Model-Based Clustering Methods.

UNIT V

Introduction to different applications of Data Mining: Time Series and Sequence Data Mining, Graph Mining, Social Network Analysis, Spatial Data Mining, Multimedia Data Mining, Text Mining, Mining the World Wide Web. Additional Themes on Data Mining and Social Impacts of Data Mining.

Suggested Reading:

1. Data Mining – Concepts and Techniques - Jiawei Han & Micheline Kamber, Morgan Kaufmann Publishers, 2nd Edition, 2006.
2. Introduction to Data Mining – Pang-Ning Tan, Michael Steinbach and Vipin Kumar, Pearson education.
3. Data Warehousing in the Real World – Sam Aanhory & Dennis Murray Pearson Edn Asia.
4. Data Warehousing Fundamentals – Paulraj Ponnaiah Wiley student Edition
5 Data Mining Introductory and advanced topics –Margaret H Dunham, Pearson education
6. Data Mining Techniques – Arun K Pujari, University Press.

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Course Type	:	**Elective**
Course Title	:	**Data Science**
Course Code	:	**SBS CSIT 030104 E 5016**
Contact Hrs per week	:	**6**
Credit	:	**6**

Course Objective and Learning Outcomes:
This course offers a comprehensive introduction to data science, covering exploratory data analysis, data preprocessing, and visualization techniques. It explores key machine learning algorithms, probability and statistical methods, and foundational mathematics including linear algebra and calculus. Students will gain both theoretical understanding and practical skills essential for analyzing and modeling data effectively.

UNIT 1
Exploratory Data Analysis: Types of Data, Data Cleaning and Preprocessing: Handling missing data, Feature Engineering: Log transform, one-hot encoding, Label encoding, Binning, Scaling; Dimensionality Reduction, Outlier detection: Z-score, IQR method, Boxplots, Mahalanobis distance; Data visualization: Matplotlib, Seaborn; Correlation and covariance, Data Science Lifecycle.

UNIT 1I
Type of Learning Techniques, Supervised Learning: Linear Regression, Logistics Regression, Decision Tree, Naïve Bayes, SVM, ANN, Clustering Techniques, Reinforcement Learning.

UNIT 1II
Probability and Statistics for Data Science: Probability, Probability Distributions- Binomial, Gaussian; Conditional Probability, Bayes' theorem, Sampling- Random sampling, stratified sampling, Cluster sampling.

UNIT 1V
Linear Algebra: Vectors and operations. Matrices: multiplication, inversion, Eigen values and eigen vectors, Principal Component Analysis, Tensors.

UNIT V
Calculus: Differentiation, Partial differentiation, Rules of differentiation (product, quotient, chain rule), Minimization and maximization of a function- local vs. global extrema, Gradient descent.

Suggested Reading:

1. Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk From The Frontline. O'Reilly, 2013.
2. Jure Leskovek, Anand Rajaraman and Jeffrey Ullman. Mining of Massive Datasets, v2.1, Cambridge University Press.
3. Jason Brownlee, Calculus for Machine Learning, Machine Learning Mastery, 2019.
4. Gilbert Strang, Linear Algebra and Learning from Data, Wellesley-Cambridge Press, 2019.
5. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, O'Reilly Media, 3rd Edition, 2022.
6. James D. Miller, Statistics for Data Science, CreateSpace Independent Publishing Platform, 2015.
7. Joel Grus, Data Science from Scratch, O'Reilly Media, 2019.

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Course Type	:	**Elective**
Course Title	:	**Quantum Computing**
Course Code	:	**SBS CSIT 030105 E 5016**
Contact Hrs per week	:	**6**
Credit	:	**6**

Course Objective and Learning Outcomes:
This course aims to introduce the fundamentals of quantum computation. This course provides an interdisciplinary introduction to the emerging field of quantum computer science, explaining basic quantum mechanics, quantum entanglement, its structure and its physical consequences and introduces quits.

UNIT 1
Complex numbers, Complex vector spaces, inner products and Hilbert spaces, Operations and matrices: Hermitian, unitary, identity, and pauli matrices, Tensor products of vector spaces, Schrodinger's time dependent equation, state vectors and wave functions.

UNIT 1I
Basics of Quantum theory, Postulates of Quantum Mechanics, Dirac Notation (Bra-Ket), Bits and Qubits, Classical gates versus quantum gates, single qubit and multiple qubit gates, Deterministic, probabilistic, and quantum systems, Stern-Gerlach experiment, electron spin, superposition of states, entanglement

UNIT 1II
Bell States, No-cloning theorem, superdense encoding, BB84 protocol, Bit-flip, phase-flip;

Quantum Circuits and modelling, Deutsch's Algorithm, Deutsch-Jozsa Algorithm, Simon's periodicity algorithm, Grover's search algorithm, Shor's Factoring algorithm.

UNIT 1V
Quantum programming languages, hybrid quantum-classical computation, Quantum tools and platforms (Qiskit, IBM Quantum Lab).

UNIT V
Emerging applications of quantum computing in optimization, machine learning, and quantum simulation. Discussion on quantum supremacy, scalability challenges, and future directions in quantum technologies.

Reference Books:

1. Michael A. Nielsen, Isaac L. Chuang, "Quantum Computation and Quantum Information", Cambridge University Press, 2010.
2. Frank Harkins, James Weaver, Jesse Sveen, "Learn Quantum Computing with Python and Qiskit", Packt Publishing, 2020.
3. Jack D. Hidary, "Quantum Computing: An Applied Approach", Springer, 2019.
4. Robert S. Sutor, "Dancing with Qubits: How quantum computing works and how it can change the world", Packt Publishing, 2019.

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Course Type	**: Elective**
Course Title	**: Ad-Hoc & Sensor Networks**
Course Code	**: SBS CSIT 030106 E 5016**
Contact Hrs. per week	**: 6**
Credit	**: 6**

Course Objectives and Learning Outcomes:

The proposed course covers a special class of wireless networks i.e. Ad-Hoc Networks in which the structure of networks varies over time. The objective of the course is to describe the basics of Ad-hoc & Sensor Networks. Students will study the major obstacles in the establishment and efficient management of Ad-hoc and Sensor Networks. The course focuses on applying energy management policies in routing algorithms and understanding the nature and applications of Ad-hoc and sensor networks. Upon successful completion of the course, the student will be able to:

- Identify different issues in wireless ad hoc and sensor networks.
- Analyze energy management issues in Ad-hoc networks for better network formation.
- Able to Design and Develop new routing protocols for ad hoc and sensor networks.
- Establish a Sensor network environment for different types of applications.

Unit-I

Introduction to Ad Hoc Networks, Data Transmission, Basics of Wireless, Sensors and Applications, Data Retrieval in Sensor Networks, Sensor Network Platforms and Tools. ROUTING: Cellular and Ad hoc wireless networks, Issues of MAC layer and Routing: Proactive, Reactive, and Hybrid Routing protocols, Multicast Routing, Tree-based and Mesh-based protocols, Multicast with Quality-of-Service Provision.

Unit-II

QUALITY OF SERVICE: Real-time traffic support – Issues and challenges in providing QoS-Classification of QoS Solutions, MAC layer classifications, QoS Aware Routing Protocols, Ticket-based and Predictive location-based QoS Routing Protocols

Unit-III

ENERGY MANAGEMENT AD HOC NETWORKS: Need for Energy Management, Classification of Energy Management Schemes, Battery Management and Transmission Power Management Schemes, Network Layer and Data Link Layer Solutions, System power Management Schemes.

Unit-IV

MESH NETWORKS: Necessity for Mesh Networks, MAC enhancements, IEEE 802.11s Architecture. Opportunistic Routing, Self Configuration and Auto Configuration, Capacity Models, Fairness, Heterogeneous Mesh Networks, Vehicular Mesh Networks.

Unit-V

SENSOR NETWORKS: Introduction, Sensor Network architecture, Data Dissemination, Data Gathering, MAC Protocols for Sensor Networks, Location Discovery, Quality of Sensor Networks, Evolving Standards –

Other Issues – Recent trends in Infrastructure less Networks

Suggested Readings:

1. Ad Hoc and Sensor Networks – Theory and Applications, Carlos Cordeiro Dharma P. Aggarwal, World Scientific Publications, March 2006, ISBN – 981-256-681-3
2. Wireless Sensor Networks: An Information Processing Approach, Feng Zhao, Leonidas Guibas, Elsevier Science, ISBN – 978-1-55860-914-3.
3. C. Siva Ram Murthy and B.S. Manoj, —Ad hoc Wireless Networks – Architectures and Protocols, Pearson Education, 2004
4. Feng Zhao and Leonidas Guibas, —Wireless Sensor Networksl, Morgan Kaufman Publishers, 2004.

C.K.Toh, -Adhoc Mobile Wireless Networksll, Pearson Education, 2002.

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Course Type	**: Elective**
Course Title	**: Artificial Intelligence & Machine Learning**
Course Code	**: SBS CSIT 030107 E 5016**
Contact Hrs. per week	**: 6**
Credit	**: 6**

Course Objectives and Learning Outcomes:

The objective of the course is to present an overview of artificial intelligence (AI) principlesand approaches. Developing a basic understanding of the building blocks of AI as presented in terms of intelligent agents: Search, Knowledge representation, inference, logic, and learning. Students will implement a small AI system in a team environment. Upon successful completion of the course, the student will be able to:

- Design a knowledge-based system.
- Ability to apply AI techniques for problem-solving.
- Use classical AI techniques, such as search algorithms, minimax algorithms, and neural networks.

Unit-I

Introduction to Intelligent System: AI, Man Vs Computers, Simulation of Intelligent Behavior, AI techniques, Intelligent Agent. Application of Intelligent Systems

Unit-II

Expert System: Introduction, basic Architecture, Types of problems solved by Expert System, Features, Limitations, Knowledge Elicitation/Acquisition: Stages of Knowledge acquisition, Techniques of Knowledge Elicitation, Expert System Tools, Application of Expert System Technologies.

Unit-III

Basic concepts and fundamental problems in Image preprocessing, Image Digitization and its properties, Image preprocessing Spatial Domain Filtering, Filtering in the Frequency Domain, Image Restoration, Image Compression, Wavelet-based Image Compression, Morphological Image Processing, Image Segmentation, Image Representation and description.

Unit-IV

Machine Learning: Introduction, Algorithmic models of learning. Learning Classifiers, probabilistic models, value functions, behaviors and programs from experience, Bayesian, maximum a posteriori, and minimum description length frameworks, Decision trees

Unit-V

Neural networks, support vector machines, Bayesian networks, bag of words classifiers, N-gram models; Markov and Hidden Markov models. Introduction to Neural networks, types, and examples of neural networks.

Suggested Readings:

1. Russel, S. and Norvig, P. (2003). Artificial Intelligence: A Modern Approach. 2nd Edition. New York; Prentice-Hall.

2. Digital Image Processing: Rafel C. Gonzalez Richard E. Woods, Second edition, Addison-Wisley
3. Peter Jackson, Introduction to Expert System (3rd Edition), Addition Wesley.
4. Bishop, C. (2006). Pattern Recognition and Machine Learning. Berlin: Springer- Verlag.