



School of Computer Science & IT Devi Ahilya Vishwavidyalaya

SYLLABUS

Ph.D Coursework (Computer Science)

Program Educational Objectives (PEOs)

- PEO 1:** Demonstrate the ability to identify, analyze, and address complex problems in computer science using innovative approaches, fostering solutions with practical applications.
- PEO 2:** Publish high-quality research publications and effectively disseminate their findings to the professional community.
- PEO 3:** Promote collaborations and consultancy services at the national and international levels in academia and industry.
- PEO 4:** Develop the ability to understand real-life problems and provide automated

Program Specific Outcomes (PSOs)

- PSO 1:** Proficient in formulating research questions, designing experiments, conducting systematic investigations, and generating innovative solutions in core and other emerging areas of computer science.
- PSO 2:** Exhibit expertise in applying advanced computational techniques, algorithms, and methodologies to solve complex problems in specialized areas of computer science.

FACULTY of ENGINEERING SCIENCES

IC-4929: Research Methodology (For Electronics, Computer Science & IT)

Unit-I

Scientific Process: Meaning and Definition, a brief history of scientific process.

Introduction of Research Methodology: Meaning of research, objectives of research, types of research, significance of research, problems encountered by researchers in India.

Research Problem: Definition, necessity and techniques of defining research problem. Formulation of research problem. Objectives of research problem.

Research Design: Meaning, need and features of good research design. Types of Research Designs, Basic Principles of Experimental Designs. Design of experiments.

Unit-II

Sampling Techniques: Census and Sample surveys, characteristics of good sample design Different Types of Sampling Techniques Simple Random, Stratified and Systematic sampling.

Unit-III

Data Collection: Primary and secondary data. Methods of collecting primary and secondary data. Various of measures of characterization of data and distributions.

Unit-IV

Testing of Hypothesis: Definition, elements of testing of hypothesis- simple & compound hypothesis, null & alternate hypothesis, degrees of freedom, level of significance, errors of two kinds, Parametric tests- t, F, Z Chi-square etc. and nonparametric tests- Run, Median, Mann Whitney etc. for testing of hypothesis, Limitations of tests of hypothesis.

Unit-V

Simulation and Modeling: Definition, Computer simulation and its need, Systems, Models- Types of models, Simulation languages.

Paper Writing and Report Generation: Basic concepts of paper writing and report generation, review of literature, Concepts of Bibliography and References, significance of report writing, steps of report writing, Types of Research reports, Methods of presentation of report.

Reference Book(s):

1. Montgomery, Douglas C. (2007), 5/e, Design and Analysis of Experiments, (Wiley India)
2. Montgomery, Douglas C. & Runger, George C. (2007), 3/e, Applied Statistics & Probability for Engineers (Wiley India)
3. Kothari C.K. (2004), 2/e, Research Methodology- Methods and Techniques (New Age International, New Delhi)
4. Krishnaswamy, K.N., Sivakumar, Appa Iyer and Mathiranjani M. (2006), Management Research Methodology; Integration of Principles, Methods and Techniques (Pearson Education, New Delhi)
5. The complete reference Office Xp – Stephan L. Nelson, Gujulia Kelly (TMH)
6. Basic Computer Science and Communication Engineering – R. Rajaram (SCITECH)

7. Book for Open Office.
8. Payer, T.A, Introduction to simulation, McGraw-Hill, 1982.
9. Gorden, G System Simulation, Prentice Hall, 1978.
10. Rietman, J Computer Simulation Application, Wiley, 1971.
11. Francis Neelamkavil, Computer Simulation and Modeling, John Wiley & Sons.

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IC-4930: Research & Publication Ethics

Unit-I

RPE-01: Philosophy and Ethics

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

Unit-II

RPE-02: Scientific conduct

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

Unit-III

RPE-03: Publication Ethics

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

Unit-IV

RPE-04: Open access publishing

1. Open-access publications and initiatives
2. SHEPRA/RoMEO online resources to check publisher copyright and 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 suggestions etc.

Unit-V

RPE-05: Publication Misconduct

A. Group Discussion

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

B. Software tools

Use of plagiarism software like Turnitin, Urkund and other open sources software tools

Unit-VI

RPE-06: Databases and Research Metrics

A. Databases:

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

B. Research Metrics

1. Impact factor of journal as per Journal Citation Reports, SNIP, SJR, IPP, Cite score
2. Metrics-h-index, g-index, i10 index, altmetrics

Text Books:

- Upendra Pratap Singh, Ms. Sakshi Ahlawat, Dr. Sushma Sharma, "Research and Publication Ethics", Sultan Chand and sons, 2023.

Reference Book(s):

- Partha Pratim Ray, "A Guide to Research and Publication Ethics", New Delhi Publisher, 2022.
- S.B.Kishor, Ajay S.Kushwaha and Gitanjali J, "Research and Publication Ethics", Das Ganu Prakashan, 2023.

IC-5931: Computer Applications (For PhD Coursework in Computer Science & IT)

Unit-I

Advanced Processors- Microprocessors, An Introduction to Assembly Language, Pipe Lining, Multi-threaded Processors, Multi-core Processors, Parallel Processors, Vector Processors, Virtual Memory Management.

Unit-II

Design & Analysis of Algorithms- Algorithm, Time & Space complexity, Sorting Techniques, Greedy & Dynamic programming, Randomized algorithms, Recursion, Divide-and-Conquer techniques.

Unit-III

Object-Oriented Design & Analysis: Problem-solving and program design techniques using the principles of object-oriented programming practices, Analysis & Design using UML.

Unit-IV

Machine Learning: Introduction, Applications, Types of the learning system, Concept learning, General-to-specific ordering of hypotheses.

Evaluation of Learning Algorithms: Measuring the accuracy of learned hypotheses, cross-validation, learning curves, Overfitting, Bias-Variance Trade-off, Data Preprocessing, Feature Selection.

Unit-V

Supervised Learning: Linear Regression, Logistic Regression, k-Nearest Neighbor (k-NN) classifier, Naïve Bayes classifier

Artificial Neural Network: Introduction, Early Models, Multilayer Perceptron, Backpropagation algorithm.

Deep Learning: Introduction, Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN)

Reference Book(s):

- John L. Hennessy and David A. Patterson, "Computer Architecture: A Quantitative Approach", 5th Edition, Morgan Kaufman, 2017
- Thomas H. Cormen, Charles E. Leiserson and Ronald L. Rivest, Introduction to Algorithms, Fourth edition, Prentice Hall of India, 2022.
- Grady Booch et al, Object-Oriented Analysis and Design with Applications, Third Edition, Pearson.
- James Rumbaugh et al, Object-Oriented Modeling and Design with UML, Second Edition, Paperback.
- Tom M. Mitchell, "*Machine Learning*", Tata McGraw-Hill Education, 2017.
- Ethem Alpaydin, "*Introduction to Machine Learning*", PHI, Third Edition, 2015.

Advance Courses in the Relevant Subjects

(For Computer Science & IT)

CS-5713: Data Analytics

Prerequisites: Master's degree in Computer Science, Information Security or related fields.

Objective: To provide doctoral scholars with an advanced understanding of soft computing techniques and their integration and algorithmic implementations.

Unit-I

Genetic Algorithms, Neural Networks, and Chaos Theory

Introduction to Expert Systems, Fuzzy Logic, Neural Networks, and Chaos Theory, Introduction to Biologically Inspired Algorithms, Introduction to Genetic Algorithms in Search and Optimization, Genetic Algorithms (GAs) and Their Mathematical Foundations.

Unit-II

Genetic Algorithms Theory and its Working

Genetic Algorithm (GA) Methodology and Its Internal Working, Understanding Genetic Algorithm (GA) Operators Step by Step, Operator Control Parameters and Fine Tuning of Genetic Algorithms (GAs), Advance GA Operators and Techniques in Search and Optimization.

Unit-III

Genetic Algorithms in Finance

Genetic Algorithms (GAs) and Stock Trading Systems, Synergistic Market Analysis, Technical Analysis, and Various Indicators, Using Genetic Algorithms to Develop Investment Strategies, Developing a Single Indicator or Multiple Indicator Market Timing System.

Unit-IV

Genetic Algorithms in Other Areas

Some Other Applications of Genetic Algorithms (GAs), Introduction to Some Other Nature-Inspired Algorithms

Unit-V

Statistical Tools for Research

Working of SPSS Software, Various types of test, regression and correlation, Technical indicators and time series modeling, ARIMA and GARCH model.

CS- 6315: Advance Software Engineering

Unit-I

Software development approaches

Evolution of Software Engineering Methodology, Applications of Process Models, Comparative Study of Process Models.

Unit-II

Software testing

White-box testing, Black-box Testing, Test driven development, Levels of testing, Automation testing, Study of testing tools.

Unit-III

Software architecture

Importance and Applications of Software Architecture; Elements of architecture, Evaluation methods of Software Architecture, Documenting software architecture, Design patterns.

Unit-IV

Agile software engineering

Agile practices, Agile Methods: XP, Scrum, Kanban, and Lean startup. Tools for agile project management.

Unit-V

Empirical software engineering

Matrices and measurements, Empirical Software Engineering, Empirical analysis methods, COCOMO model, Phase wise metrics.

Text Books:

1. A practitioner's approach to Software Engineering by Pressman, 2005.
2. Software testing by Aditya Mathur, 2008.
3. Software architecture in Practice by Len Bass, 2007.
4. Agile software development by Cockburn, 2000.
5. Empirical software engineering by Yogesh Singh
6. Design Patterns by Eric Gamma et al.

CS-6423: Advanced Database Management Systems

Unit-I

Overview of Advanced DBMS Concepts: Relational Database, Object Relational Database, NoSQL database. Introduction for Object Relational Database, implementing user-defined types, Object-relational features in PostgreSQL /Oracle, Object view and Methods, Collectors (Nested Tables and Varying Arrays), The Emergence of NoSQL.

Unit-II

NoSQL Data Architecture: Introduction to NoSQL Database, data models (Document, Columnar, Key-Value, Graph), ACID and BASE for reliable database transactions, Brewers CAP theorem.

Unit-III

Document Oriented Database: Document Oriented NoSQL Database, data model, CRUD, Aggregation framework.

Unit-IV

Columnar Database/ Column-Family stores: Column-oriented NoSQL databases using Apache Cassandra, data model, Query operations, Partitioning and Sharding.

Unit-V

Key-Value and Graph database: Essential features of key value Databases, Properties of keys, Key-Value Database Data Modeling Terms, Graph Model, Property Graph Model, Graph NoSQL databases using Neo4, Querying Graphs using Cypher language.

Text Books and References:

1. Kevin Loney, "Oracle Database 10g: The Complete Reference", Oracle Press, McGraw-Hill
2. Pramod J. Sadalage, Martin Fowler, "NoSQL Distilled", Addison-Wesley
3. Ian Robinson, Jim Webber, "Graph Databases", O'Reilly
4. Eben Hewitt, "Cassandra: The Definitive Guide", O'Reilly
5. Kristina Chodorow, "MongoDB: The Definitive Guide", O'Reilly

CS-6518: Cloud Computing

Unit-I

Cloud Fundamentals: Cloud Definition, Evolution, Architecture, Applications, Characteristics, deployment models and service models.

Virtualization: Issues with virtualization, virtualization technologies and architectures, Issues of virtual machine monitors/hypervisors, virtualization of data centers, Types of Virtualization- Introduction to

Unit-II

Service models - Infrastructure as a Service (IaaS) - Resource Virtualization: Server, Storage, Network - Case studies: AWS components and services, Infrastructure as a Code

Platform as a Service (PaaS) - Cloud platform & Management: Computation, Storage- Case Studies, Software as a Service (SaaS) , Anything as a service (XaaS). Multi-tenant Architecture.

Unit-III

Private, Public, Hybrid, Community and Multi Cloud. Cloud Programming and Software Environments – Parallel and Distributed Programming paradigms – MapReduce and its extensions to Cloud Computing, Containers, Kubernetes, DevOps.

Unit-IV

Security: Vulnerability Issues and Security Threats, Application-level Security, Data level Security, and Virtual Machine level Security, Infrastructure Security, and Multi-tenancy Issues. IDS: host-based and network-based, Security-as-a-Service. Trust Management, Identity Management, Advances: Mobile Cloud Computing, Fog Computing, Edge Computing, Green Cloud.

Unit-V

Cloud Simulators and research tools, Research issues associated with cloud Computing: Deployment of Cloud Services, Data Security and Privacy, Scalability and, Load Balancing, Energy Efficiency and Sustainability, Interoperability and Portability, Latency and Real-Time Data Processing, Fault Tolerance and Reliability, Quality of Service (QoS) Management, Data Management and Storage Optimization, Edge and Fog Computing Integration, AI and Machine Learning in Cloud Operations

Text Books:

1. R. Buyya, C. Vecchiola, and S. T. Selvi, *Mastering Cloud Computing: Foundations and Applications Programming*. New Delhi, India: Tata McGraw-Hill, 2013.
2. K. Jayaswal, J. Kallakurchi, D. J. Houde, and D. Shah, *Cloud Computing Black Book*. New Delhi, India: Dreamtech Press, 2014.
3. G. Shroff, *Enterprise Cloud Computing: Technology, Architecture, Applications*. Cambridge, U.K.: Cambridge University Press, 2010.
4. A. T. Velte, T. J. Velte, and R. Elsenpeter, *Cloud Computing: A Practical Approach*. New Delhi, India: Tata McGraw-Hill, 2009.
5. K. Chandrasekaran, *Essentials of Cloud Computing*. Boca Raton, FL, USA: CRC Press, 2014.

CS-6647: Mobile Communication

Course Objectives:

To provide an in-depth understanding of mobile communication fundamentals, optimization techniques, and emerging 5G/6G technologies; to enable students to analyze, design, and optimize mobile networks for future applications.

Course Outcomes:

Students will be able to explain and analysis of wireless communication principles, apply optimization strategies to mobile systems, and critically evaluate advanced technologies in 5G and 6G networks.

Unit-I

Introduction to Mobile Communication

Evolution of Mobile Communication (1G to 6G) - Overview of Wireless Communication Systems - Basic Cellular Concepts: Frequency Reuse, Cell Splitting, Handoff - Channel Assignment Strategies - Multiple Access Techniques: FDMA, TDMA, CDMA, OFDMA

Mobile Radio Propagation: Radio Wave Propagation Basics - Free Space and Multipath Propagation - Path Loss Models (Okumura, Hata, COST-231) - Shadowing and Fading (Fast vs. Slow Fading) - Diversity Techniques (Space, Frequency, Time Diversity)

Unit-II

Mobile Communication Systems:

GSM Architecture and Protocols - GPRS and EDGE Technologies - 3G (UMTS, CDMA2000) Systems - LTE and LTE-Advanced Architecture - Voice over LTE (VoLTE).

Unit-III

5G Mobile Networks:

Introduction to 5G NR (New Radio) - 5G Architecture: Core Network (5GC) and Access Network (NG-RAN) - Key Technologies: Massive MIMO, mmWave communication, Beamforming, Network Slicing - Mobile Edge Computing (MEC) - 5G Protocol Stack (Layers and Interfaces) - 5G Use Cases: eMBB, URLLC, mMTC.

Unit-IV

Emerging Concepts and 6G Vision:

Introduction to 6G: Goals and Challenges - Terahertz Communication - AI/ML in 6G Networks - Intelligent Reflecting Surfaces (IRS) - Cell-Free Massive MIMO - 6G Applications: Holographic Communication, Tactile Internet - Green Communications and Sustainability in 6G - 6G Standardization Efforts (ITU, 3GPP Pre-study).

Unit-V

Optimization, Security and Privacy in Mobile Networks:

Optimization: Network Planning and Resource Allocation - Power Control and Interference Management - Spectrum Efficiency and Energy Efficiency - Handover Optimization - Load Balancing Techniques - QoS Optimization in Mobile Networks.

Security and Privacy in Mobile Networks: Security Issues in 4G/5G Networks - Authentication and Encryption - 5G Security Architecture - Privacy Concerns in Future Networks (5G/6G)

Text Books and References:

1. Rappaport, Theodore S. *Wireless communications: principles and practice*. Cambridge University Press. (Unit 1 and 2)
2. Dahlman, Erik, Stefan Parkvall, and Johan Skold. *5G NR: The next generation wireless access technology*. Academic Press, 2020. (Unit 3)
3. Wu, Yulei, et al., eds. *6G mobile wireless networks*. Berlin, Germany:: Springer, 2021. (Unit 4)
4. 3GPP Technical Reports (for 5G/6G standards) (Unit 3,4 and 5)

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CS- 6648: Network and Information Security

Prerequisites:

Master's degree in Computer Science, Information Security or related fields.

Objective:

To provide doctoral scholars with an advanced understanding of network and information security principles, frameworks and current research trends, including blockchain integration and algorithmic implementations.

Unit-I

Theoretical Foundations and Cryptographic Advancements

Security Concepts and Theoretical Foundations: CIA Triad, Attack Surfaces, Threat Modeling

Advanced Algorithms: Symmetric (AES, DES, RC4), Asymmetric (RSA, ElGamal), Hashing (SHA-2, SHA-3, MD5), Key Exchange (Diffie–Hellman), AES-GCM, RSA with OAEP, ECC

Digital Signatures and Certificates: Public Key Infrastructure (PKI)

Quantum-resistant Algorithms: Lattice-based, Code-based cryptography

Authentication Protocols: Kerberos, RADIUS, SAML, OAuth

Review of Current Literature and Open Research Problems

Unit-II

Advanced Network Security Architectures and Protocols

Architectures of Secure Network Infrastructures: AI-based IDS/IPS

Secure Routing Protocols: Ad-hoc and IoT Networks

Protocol Analysis: Formal Methods and Verification (ProVerif, Tamarin)

Address Translation, Proxy and Port Knocking Mechanisms

VPN Protocols and Secure Tunneling: IPsec, L2TP, OpenVPN

Emerging Trends: Zero Trust Network Architecture (ZTNA), Software-Defined Perimeter (SDP)

Unit-III

System Security, Malware Research and Trusted Computing

Advanced Operating System Security Mechanisms

Access Control: Formal Logics and Delegation Models

Trusted Computing and TPM 2.0

Research in Malware Analysis: Machine Learning for Detection, Polymorphic Malware

Authentication Mechanisms: Passwords, Biometrics, Multi-Factor Authentication (MFA)

Secure Application Design and Runtime Enforcement Techniques

Review of Literature on Attack Vectors and Defensive Systems

Unit-IV

Cybersecurity Risk, Compliance and Blockchain Research

Cybersecurity Frameworks: ISO 27001, NIST RMF

Legal and Regulatory Aspects: GDPR, IT Act, HIPAA, PCI-DSS

Security Metrics and Quantitative Risk Assessment

Digital Forensics with Chain of Evidence Preservation and AI-assisted Tools

Blockchain: Smart Contract Security and Formal Verification (Solidity, Vyper, SMT solvers) Consensus Algorithm Comparisons: PoW, PoS, DAG, PBFT and Hybrid Models, Cross-chain Protocols and Interoperability Challenges

Unit-V

Tools and Frameworks for Security Research

Network Monitoring: Wireshark, Zeek (formerly Bro), NetFlow Analyzer

Vulnerability Analysis: Metasploit Framework, OpenVAS, Burp Suite Pro

Protocol Simulation and Verification: NS-3, Tamarin, ProVerif

Blockchain Environments: Ethereum Testnet, Hyperledger Fabric, Truffle Suite

Security Visualization: ELK Stack, Maltrail, Grafana

Digital Forensics: The Sleuth Kit, Volatility, Rekall Framework

Machine Learning for Threat Detection: Scikit-learn, TensorFlow Security Models

CS-6706: Image Processing and Computer Vision

Objective:

The learning objectives of this course are to cover the basic theory and algorithms that are widely used in digital image processing and computer vision.

Unit-I

Digital Image Fundamentals: Image sampling & quantization; Basic relationships between pixels, Mathematical tools used in digital image processing. Human Visual System.

Image Enhancement: Overview, Contrast Intensification, Smoothing, Sharpening, Basic intensity Transformation functions, Histogram processing, Spatial filters, Image Restoration.

Unit-II

Color Image Model: Color representation, Chromaticity diagram, Color Coordinate Systems.

Image Transform: Discrete Fourier Transform, Image Enhancement in Frequency Domain.

Unit-III

Image Compression: Fundamentals, Lossless Compression - Huffman Coding, Arithmetic Coding, LZW Coding, Run-length Coding. Lossy Compression - JPEG Coding.

Image Segmentation: Fundamental concepts, Segmentation: Region extraction, Pixel-based approach, Thresholding, Region-based approach. Canny Edge Detection.

Unit-IV

Feature Extraction: Representation, Topological Attributes, Geometrical Attributes, Spatial Moments, Boundary-based Description, Region-based Description, and Intensity-based Description.

Unit-V

Computer Vision: Fundamentals, Histogram of Oriented Gradient(HOG), Scale Invariant feature transform (SIFT), Local Binary Pattern (LBP), Gray-level co-occurrence matrix (GLCM), Moving object detection - Background Subtraction approach, moving object detection using Gaussians Mixture Model (GMM) approach. Object Tracking, Kernel (Mean Shift) based Object Tracking.

Reference Book(s):

1. R. C. Gonzalez and R.E. Woods, "Digital Image Processing", Fourth Edition, Prentice Hall, 2018.
2. D.A. Forsyth and J. Ponce, "Computer Vision: A Modern Approach", Second Edition Prentice Hall, 2015
3. Bhabatosh Chanda, D. Dutta Majumder, "Digital Image Processing and Analysis", Second Edition, PHI, 2013.
4. Anil K. Jain, "Fundamentals of Digital Image Processing", Prentice-Hall, 2011.

Online Resources:

1. NPTEL Course Video Lectures on "Digital Image Processing" - By Prof. Prabir Kumar Biswas IIT Kharagpur.
2. NPTEL Course Video Lectures on "Computer Vision And Image Processing - Fundamentals And Applications" – By Prof. M. K. Bhuyan, IIT Guwahati.