Department of Computer Science & Engineering

University of Kalyani

Syllabus for Ph.D. Coursework

2022

Paper – 1: Research Methodology (A) [Paper Code: RM/A]

Credits Allotted: 04 **Total Marks: 100**	**Research Methodology and Statistics**	**Research Ethics**	**Computer Applications**
Marks allotted for end-semester examination	30	15	15
Marks allotted for Internal Assessment	10	5	5
Marks allotted for Viva-Voce examination	10	5	5
Total	**50**	**25**	**25**

Syllabus will be same as central syllabus and the classes will be conducted centrally at the university level.

Paper – 2: Research Methodology (B) [Paper Code: RM/B]

Credits Allotted: 04 **Total Marks: 100**	**Literature Review**	**Submission of reports on review work**	**Paper presentation**
Marks allotted for end-semester examination	30	15	15
Marks allotted for Internal Assessment	10	5	5
Marks allotted for Viva-Voce examination	10	5	5
Total	**50**	**25**	**25**

This paper will be conducted by the students under the supervision of respective supervisor. The supervisor will be responsible to submit the marks for this paper.

Paper – 3: Advanced Level Course on Subject (A) [Paper Code: ALC/A]

Credits Allotted: 04 **Total Marks: 100**	**Advanced Level Subject-Specific Components**
Marks allotted for end-semester examination	60
Marks allotted for Internal Assessment	20
Marks allotted for Viva-Voce examination	20
Total	**100**

Syllabus: The student will choose one of the following papers in consultation with the supervisor.

- Pattern Recognition
- Image Processing
- Remote Sensing and GIS
- Network Security
- Authentication and Steganography
- Coding Theory and Data Compression
- Advanced Algorithms and Multidimensional Search Techniques
- Soft Computing
- Bioinformatics and Computational Biology
- Data Mining
- Optical and Sensor Networks
- Semantic Web and Link Data
- Wireless and Mobile Systems
- Cloud Computing
- Blockchain Technologies

The detailed syllabi of the papers are given in annexure A.

Paper – 4: Advanced Level Course on Subject (B) [Paper Code: ALC/B]

Credits Allotted: 04 **Total Marks: 100**	**Advanced Level** **Transdisciplinary Components**
Marks allotted for end-semester examination	60
Marks allotted for Internal Assessment	20
Marks allotted for Viva-Voce examination	20
Total	**100**

Syllabus: [Each student will choose any four of the five modules.]

Module 1: Algorithms and data structure fundamentals, asymptotic notations, types of data structure, various algorithm paradigms and approaches, sorting and searching algorithms, deterministic and randomized algorithms, metaheuristic randomized search algorithms, fundamentals of computational geometry

Module 2: Data science & data analytics applications, use of statistics in computing, introduction to big data and data analytics, concept of machine learning methods, clustering, association rule mining, regression and classification techniques.

Module 3: Digital image and video processing, image and video representation, image transformation, restoration, compression, segmentation, computer vision fundamentals, pattern recognition techniques, feature extraction and selection, pattern classification, fuzzy sets and fuzzy logic, fuzzy inference systems, neural network fundamentals.

Module 4: Computer networks, communication fundamentals, network and cyber security, fundamentals of cryptography, blockchain technologies, authentication techniques, steganography methods, data compression, coding theory fundamentals.

Module 5: Optical and sensor networks, wireless and mobile networks, cloud computing fundamentals, semantic webs, remote sensing and GIS technologies, real-time and embedded systems, high-performance computing.

Annexure A

Detailed Syllabus for Paper – 3 [ALC/A]

Image Processing & Pattern Recognition

Introduction: Digital Image representation; Fundamental steps in Image processing, Elements of digital Image processing systems.
Digital Image Fundamentals: Sampling and quantization, imaging geometry.
Image Transforms: Fourier, Walsh, Hademord, discrete cosine and Hotelling transforms and their properties.
Image Enhancement: Enhancement by point processing, spatial filtering, Frequency domain enhancement, Color image processing.
Image Restoration: Unconstrained and constraint restoring, inverse filtering, Wiener Filter, Geometric transforms.
Image Compression: Image Compression models, Error-free compression, Lossy compression, Image compression standards.
Image Segmentation: Detection of discontinuities, edge linking, Thresholding.
Representations and Descriptions: Chain codes, shape numbers, moments and Fourier and other descriptors. Recognition & Interpretations.

Introduction to Pattern Recognition, Definitions, data sets for Pattern Recognition, Different Paradigms of Pattern Recognition, Representations of Patterns and Classes Metric and non-metric proximity measures, Feature extraction, Different approaches to Feature Selection , Nearest Neighbor Classifier and variants, Efficient algorithms for nearest neighbour classification, Different Approaches to Prototype Selection, Bayes Classifier, Decision Trees, Linear Discriminant Function, Different Approaches to Prototype Selection, Bayes Classifier
Decision Trees, Linear Discriminant Function, Support Vector Machines, Clustering, Clustering Large datasets, Combination of Classifiers, Applications - Document Recognition.

Remote Sensing and GIS

Introduction – Perspectives and concept of remote sensing, special applications. Geophysical Remote Sensing – external fields, magnetic, geophysical remote sensing: Gravity, crust dynamics seismology. Electromagnetic spectrum; The photon, Distribution of Radiant energies, Sensor technology, Spectral signatures- Interpretation and classification. Signatures and Sensors, Image Processing & Interpretation, Fundamentals of image processing, image representation, Spatial domain and transformation domain image processing, Enhancement techniques using soft computing tools in spatial as well as spectral domain, optimization based image processing. Features and classification techniques, GIS Applications, latest trends of GIS applications.

Network Security and Steganography

Uniqueness – Number Theory concepts – Primality – Modular Arithmetic – Fermet & Euler Theorem – Euclid Algorithm – RSA – Elliptic Curve Cryptography – Diffie Hellman Key Exchange
Digests – Requirements – MAC – Hash function – Security of Hash and MAC – Birthday Attack – MD5 – SHA – RIPEMD – Digital Signature Standard – Proof of DSSAuthentication applications – Kerberos – Kerberos Encryption Techniques – PGP – Radix64 – IP Security Architecture – Payload – Key management – Web security requirements – SSL – TLS – SET

Resources – Intruders and Intrusion – Viruses and Worms – OS Security – Firewalls – Design Principles – Packet Filtering – Application gateways – Trusted systems – Counter Measures
Protocols and standards – OSI model – TCP / IP protocol suite – addressing – versions – underlying technologies.
Classful addressing – other issues – subnetting – supernetting – classless addressing – routing methods – delivery – table and modules – CIDR – ARP package – RARP.
Datagram – fragmentation – options – checksum – IP package – ICMP – messages, formats – error reporting – query – checksum – ICMP package – IGMP – messages, operation – encapsulation – IGMP package – UDP – datagram – checksum – operation – uses – UDP package.
Services – flow, congestion and error control – TCP package and operation – state transition diagram – unicast routing protocols – RIP – OSPF – BGP – multicast routing – trees – protocols – MOSPF – CBT – PIM
Client server model – concurrency – processes – sockets – byte ordering – socket system calls – TCP and UDP client-server programs – BOOTP -DHCP – DNS – name space, resolution – types of records – concept – mode of operation – Rlogin.
Security & Steganograpgy: Modern tools and techniques of security, soft computing based security, Fundamentals of steganography, Spatial and transform domain steganograpgy, Hash based steganography, Handles and adjustments, Genetic Algorithm based steganography, Audio & Video steganography, latest trends on steganography.

Coding Theory and Data Compression

Digital Communication, Codes preliminaries: Block codes, Single Parity Check codes, Product code, Repetition codes, Hamming Codes, Minimum Distance Block codes, problems. Linear code: Linear Code definition, generator matrices, parity check matrices, error syndromes, error detection and correction, shortened and extended linear codes, related problems.
Cyclic codes: Concept of Cyclic codes, polynomials, generator polynomials, parity check polynomials, dual cyclic codes, generator and parity check matrices of cyclic codes, related problems.
Galois fields: Galois field elements of GF(23), GF(24), GF(25), primitive field elements, irreducible polynomials, minimal polynomial, related problems. Coding theory application, Application of coding theory in different fields.
Transformations: Basics of transformations and its utility, Fourier transformation, Discrete Fourier Transformations, Discrete Cosine Transformation, Wavelet Transformation and its varieties, Z transforms, Binomial Transformation, Group Transformations.

Advanced Algorithms and Multidimensional Search Techniques

Fundamentals: Review of asymptotic notations, review of basic data structures, and review of basic algorithms.
Sorting and Searching: Review of classical sorting and searching techniques and their analysis.
Advanced Data Structures: K-d tress, Range tress and fractional cascading, Interval Tress, Priority Search Tress, Segment Trees, Skip lists, Amortized analysis, Fibonacci Heaps, Perfect Hashing.
Divide and Conquer: Introduction, Binary Search and Merge sort, Quick Sort and their analysis, Matrix multiplication, Finding the closest pair of points.
Greedy Approach: Introduction, Shortest Path Problem, Minimum Spanning Tree problem: Prim's and Kruskal's Algorithms, Fractional Knapsack problem.
Dynamic Programming: Introduction, Longest Common Subsequence problem, Matrix chain multiplication, Knapsack problem.
Randomized Algorithms: Introduction, Las Vegas and Monte Carlo Algorithms, Contention resolution in distributed system, finding the global min-cut, Testing String Equality, Randomized Divide-and-Conquer: Median finding and Quick sort, Randomized approach for finding the closest pair of points.
Approximation Algorithm: Introduction, Polynomial Approximation Schemes: Knapsack problem, Fully Polynomial Approximation Schemes: The subset-sum problem, Center selection problem.
Techniques in Computational Geometry: Introduction, Geometric Preliminaries, the Convex Hull Problem, Computing the Diameter of a Set of Points, Line segment intersection, Polygon Triangulation: Guarding an Art gallery, Nearest-Point Voronoi Diagram, Delaunay triangulation, Line-point duality.

Soft Computing

Fuzzy Logic and Approximate Reasoning: Conventional and fuzzy sets: Basic concepts of fuzzy logic. Fuzzy expressions: Basic principles of fuzzy logic and fuzzy inference rules, fuzzy relations, fuzzy operators, realization of fuzzy systems using fuzzy relations. Application of fuzzy logic in vision, pattern recognition, robotics and linguistics. Approximate reasoning in Experts Systems, Fuzzy sets in approximate reasoning, Fuzzy propositions in approximate reasoning. Basic principles of approximate reasoning and rules of inference.
Genetic Algorithms (GAs): Introduction to GAs, Binary encodings of candidate solutions, Schema Theorem and Building Block Hypothesis, Genetic operators – crossover and mutation, parameters for GAs, Reproduction mechanism for producing Offspring, Darwinian Principle in evaluating objective function. Convergence Analysis: Simple GA schemes, Stochastic models: GA approaches to optimization problems. Multiobjective GAs. Basic Concepts and Principles of Neural Networks (NNs) and Learning Systems. Learning with GAs and Artificial NNs (ANNs); Composite use of Fuzzy Logic, ANNs and GAs. Perceptron Training, Back propagation learning, Applications in pattern classification and image understanding.

Bioinformatics and Computational Biology

Introduction to molecular biology, cell, chromosome, DNA, RNA, proteins, Central Dogma, protein structures, computational biology and bioinformatics tasks;

Sequence databases,sequence comparison, sequence alignment, local and global sequence alignment, multiple sequence alignment, web tools for sequence comparisons;

Sequencing, genome sequencing, fragment assembly, next-generation sequencing, handling errors in sequencing, gene finding, promoter identification, sequence-based protein classification;

Protein structures, structure prediction from sequence, motif finding, structure alignment, structure-based protein classification, molecular design and docking;

Phylogeny analysis, phylogenetic tree construction algorithms, parsimony and distance-based techniques;

Gene expression analysis, microarray, microarray analysis, differential expression, microarray clustering, biclustering, classification, gene marker prediction, gene selection, gene ordering, gene prioritization, gene significance analysis, gene co-expression, differential co-expression;

Biological networks, protein-protein interactions, gene regulatory networks, metabolic networks, network analysis and prediction, systems biology;

Biological databases, sequence databases, gene/protein databases, protein structure/domain databases, microarray gene expression databases, protein-protein interaction databases, gene regulatory network databases, metabolic network databases.

Data Mining

Data Mining: - Data Mining Functionalities – Data Preprocessing – Data Cleaning – Data Integration and Transformation – Data Reduction – Data Discretization and Concept Hierarchy Generation- Architecture Of A Typical Data Mining Systems- Classification Of Data Mining Systems.
Association Rule Mining: - Efficient and Scalable Frequent Item set Mining Methods – Mining Various Kinds of Association Rules – Association Mining to Correlation Analysis – Constraint-Based Association Mining.
Cluster Analysis: - Types of Data in Cluster Analysis – A Categorization of Major Clustering Methods – Partitioning Methods – Hierarchical methods – Density-Based Methods – Grid-Based Methods – Model-Based Clustering Methods – Clustering High-Dimensional Data – Constraint-Based Cluster Analysis – Outlier Analysis.
Classification and Prediction: - Issues Regarding Classification and Prediction – Nearest Neighbour Classification - Classification by Decision Tree Introduction – Bayesian Classification – Rule Based

Classification –Support Vector Machines – Associative Classification –Prediction – Accuracy and Error Measures – Evaluating the Accuracy of a Classifier or Predictor – Ensemble Methods – Model Section.
Mining Object, Spatial, Multimedia, Text and Web Data:
Multidimensional Analysis and Descriptive Mining of Complex Data Objects – Spatial Data Mining – Multimedia Data Mining – Text Mining – Mining the World Wide Web.

Optical and Sensor Networks

Computer Networks, Communication Systems, Optical Networks, Optical Fiber Principles and Operation, Wavelength Division Multiplexing (WDM) Network Architecture, Routing and Wavelength Assignment (RWA) Problems, Classification and Different Existing Heuristics, Multi-fiber WDM Networks and Different Existing Algorithms, Provisioning, Traffic Grooming, Protection and Reliability of Optical Networks.
Sensor Network and its Challenges, Different Data Gathering Techniques, Security of Sensor Networks.

Semantic Web and Linked data

Introduction: History of Web, World Wide Web, Internet, Working Mechanism of Web, Importance of Document on the Web, URL, IRI, Namespace, Domain.
Semantic Web: What is Semantic? What is Semantic Web? Semantic Web Road Map, Comparison between Semantic Web and Traditional Web, Semantic Web Layer Cake and Their Significance, Vision of Semantic Web, Short Introduction to Ontology.
Preliminary Knowledge on XML, RDF, RDFa, Microdata.
RDF (Resource Description Framework) & RDF Schema: Introduction to RDF, Different Features and Components of RDF, Detail Study of RDF Class, Property, Instances, Restriction, Domain and Range of Properties and their Use with Examples, Different Notations of RDF: RDF/XML, N3, NTRIPLES, Turtle.
Ontology: What is Ontology? Different Types of Ontology (Upper Ontology, Domain Ontology etc.), Reusability of Ontology, Heterogeneity Problem among Ontologies, Discussion about the Problem and its Solution, Different Building Blocks of an Ontology (Domain Ontology).
Linked Data Web and Semantic Web: Introduction to Linked Data, Relation between Linked Data and Semantic Web, Linked Data Principles and Design Consideration, Publishing Linked Data, Consuming Linked Data, Discussion on Traditional Web of Documents and Web of Data.
Introduction to Current Research and Development Work going on Semantic Web: Introduction to Different Stages to Develop a Complete Semantic Web Application and Linked Data, Introduction to Different Available Tools.

Wireless and Mobile Systems

Wireless Transmission-Wired and wireless, Mobility of users and equipment, Electromagnetic Spectrum,
Radio and Microwave communication, Infrared and Millimeter waves, Legthwave Transmission.
Satellite Network Architecture-Satellite Orbits-GEO LEO, MEO. Inmarsat, Iridium, Odyssey, Global Star,
Archimedes and other Satellite Networks.
Spread Spectrum and CDMA-Direct (pseudo-noise) and Frequency hopped Spread Spectrum. CDMA System.
Wireless LANs -MACA and MACAW protocols. Infrared LAN. Cellular Radio Systems-Paging, Cordless
telephones, Analog Cellular telephones AMPS. Digital Cellular Telephone-GSM. Personal Communication
service (PCS).
CDPD system.
Mobile Data Networks and their applications.

Wireless and Mobile access to the Internet.

Cloud Computing

Introduction to cloud computing – Overview of Computing, Cloud Computing NIST Model, Properties, characteristics and disadvantages, role of open standards.
Cloud computing architecture – cloud computing stack, service Models (XaaS), IaaS, Paas, SaaS, Daas, Deployment Models, private, public, hybrid, commercial cloud models.
Service management in Cloud computing – service level agreement (SLA), SLA violation, cloud economics.
Resource management in cloud computing – resource sharing, scalability, elasticity, transparency.
Data management in cloud computing – looking at data scalability and cloud services, database and data stores in cloud, large scale data processing
Cloud security – infrastructure security, data security and storage, identity and access management, access control, trust, reputation risk
Cloud simulators – CloudSim, CloudAnalyst, MultiRecCloudSim, CloudSimPlus, GreenCloudSimulator
Research trend in Cloud compting, green cloud computing, fog computing

Blockchain Technologies

Introduction of Cryptography and Blockchain: What is Blockchain, Blockchain Technology Mechanisms & Networks, Blockchain Origins, Objective of Blockchain, Blockchain Challenges, Transactions And Blocks, P2P Systems, Keys As Identity, Digital Signatures, Hashing, and public key cryptosystems, private vs. public Blockchain.
BitCoin and Cryptocurrency: What is Bitcoin, The Bitcoin Network, The Bitcoin Mining Process, Mining Developments, Bitcoin Wallets, Decentralization and Hard Forks, Ethereum Virtual Machine (EVM), Merkle Tree, Double-Spend Problem, Blockchain And Digital Currency, Transactional Blocks, Impact Of Blockchain Technology On Cryptocurrency.
Introduction to Ethereum: What is Ethereum, Introduction to Ethereum, Consensus Mechanisms, How Smart Contracts Work, Metamask Setup, Ethereum Accounts, Receiving Ether’s What's a Transaction?, Smart Contracts.
Introduction to Hyperledger: What is Hyperledger? Distributed Ledger Technology & its Challenges, Hyperledger & Distributed Ledger Technology, Hyperledger Fabric, Hyperledger Composer.
Solidity Programming:
Solidity - Language of Smart Contracts, Installing Solidity & Ethereum Wallet, Basics of Solidity, Layout of a Solidity Source File & Structure of Smart Contracts, General Value Types (Int, Real, String, Bytes, Arrays, Mapping, Enum, address)
Blockchain Applications: Internet of Things, Medical Record Management System, Domain Name Service and Future of Blockchain, Alt Coins.