DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF DELHI
DELHI-110007

PRE-PH.D. COURSE WORK LIST

Paper 1:
RCS001 - Research Methodology

Paper 2 & Papers 3:
Two papers out of the followings:
(Instead of Paper 2: One paper out of the followings):

1. RCS002 - Combinatorial Optimization
2. RCS003 - Approximation Algorithms
3. RCS004 - Special Topics in Theoretical Computer Science
4. RCS005 - Adhoc Networks
5. RCS006 - Algorithmic Graph Theory
6. RCS007 - Biometrics
7. RCS008 - Computer Security
8. RCS009 - CUDA Programming
9. RCS010 - Deep Learning
10. RCS011 - Digital Image Processing
11. RCS012 - Human Computer Interaction (HCI)
12. RCS013 - Information Hiding Techniques
13. RCS014 - Information Security
14. RCS015 - Linear Integer Programming
15. RCS016 - Machine Learning
16. RCS017 - Modern Approach to Artificial Intelligence
17. RCS018 - Neural Network
18. RCS019 - Probabilistic Graphical Models
19. RCS020 - Scalable Machine Learning
20. RCS021 - Software Quality Assurance
21. RCS022 - Software Testing
22. RCS023 - Special Topics in Artificial Intelligence (Multi-Agent Systems)
23. RCS024 - Special Topics in Computational Intelligence
24. RCS025 - Special Topics in Computer Networks
25. RCS026 - Special Topics in Data Mining
26. RCS027 - Special Topics in Database System
27. RCS028 - Special Topics in Information Security
28. RCS029 - Special Topics in Soft Computing
29. RCS030 - Swarm Intelligence
30. RCS031 - Theory of NP Completeness
**RCS002 - COMBINATORIAL OPTIMIZATION**

- **Introduction:** Optimization problems, neighborhoods, local and global optima, convex sets and functions, simplex method, degeneracy; duality.
- **Graph Algorithms:** Primal-Dual algorithm and its application to shortest path, Max-flow problems (Ford and Fulkerson labeling algorithms, Dijkstra’s algorithm, Ford-Warshall algorithms), bipartite matching algorithm, spanning tree algorithms.

Readings:

1. The course will be taught by Research Papers.

**RCS003 - APPROXIMATION ALGORITHMS**

- NP-Hardness and Approximation Algorithms.
- TSP
- Linear Programming and Duality (Vertex Cover and Matching).
- LP Rounding (Set Cover/Vertex cover)
- Dual Fitting (Greedy Set Cover)
- Local Search Technique (Facility Location)
- Primal-Dual Approximation Algorithms in Graph Connectivity and Network Design
- Iterative Rounding

Readings:

1. The course will be taught by Research Papers.

**RCS004 - SPECIAL TOPICS IN THEORETICAL COMPUTER SCIENCE**

- (NP-Completeness and Approximation)
- **Introduction** to NP-Completeness and Approximation.
- **Problems from first principle:** Satisfiability SAT, 3SAT.
- **Graphs:** Clique, Covering, Graph Partitioning, Subgraph problem, Graph Isomorphism, Graph Coloring, Hamiltonian Cycle Problem, TSP.
- **Network Design Problems:** Steiner tree, Spanning Trees, Cuts and Connectivity, Routing and Flow Problems.
- **Sets and Partitions:** Set partition and Covering, Subset sum.
- **NP-Hard problems:** Clustering Problems like k-means clustering, co-clustering, connected k-means clustering. More new problems as they are added to the class of NPC or NPH.
- **Approximation Algorithms** for the above problems.

Readings:

6. Part of the course will be covered by research papers.

- **RCS005 - ADHOC NETWORKS**
- **RCS006 - ALGORITHMIC GRAPH THEORY**
  - Introduction to Graphs, Paths, Cycles and Trails.
  - Max-Flow Min-Cut Theorem, Computing Max S-T flows and Min-Cut
  - Edge and Vertex Connectivity and Menger’s Theorem
  - Maximum matching, Hall’s Theorem, algorithms for computing maximum matching in weighted and unweighted graphs.
  - Edge and Vertex coloring of graphs. Independent sets.
  - Planar graphs and algorithms for checking for planarity.

Readings:

1. The course will be taught by Research Papers.

- **RCS007 - BIOMETRICS**
- **RCS008 - COMPUTER SECURITY**
- **RCS009 - CUDA PROGRAMMING**
- **RCS010 - DEEP LEARNING**
- **RCS011 - DIGITAL IMAGE PROCESSING**
- **RCS012 - HUMAN COMPUTER INTERACTION (HCI)**

The course needs to focus on survey of work on interactive systems, explore the current and future research areas in interaction techniques and the design, prototyping, and evaluation of user interfaces. Topics include user interface toolkits; design methods; evaluation methods; ubiquitous and context-aware computing; tangible interfaces;

Research papers on these topics need to be discussed with the background that the student is registered in Ph.D. and needs to understand the way papers present the work, conduct the experimental studies and prepare summary on these followed by presentations.

Readings:

1. The course will be taught by Research Papers.

- **RCS013 - INFORMATION HIDING TECHNIQUES**
  - Principals of Steganography and Watermarking.
  - Steganalysis - Steganalysis introduction and terminology, Detecting hiding information, Extracting hiding information, Disabling hidden information

Readings:

1. The course will be taught by Research Papers.

- **RCS014 - INFORMATION SECURITY**
  - Symmetric Key Cryptography-Classical Encryption Techniques, Block Ciphers, Data Encryption Standard(DES), Triple DES, Modes of DES, Advanced Encryption Standard, Stream Cipher and RC4
  - Public key cryptography-DH key exchanged, RSA, Elliptic Curve Cryptography, Message Authentication and Hash Function, Cryptographic hash function, Non Cryptographic Hash function, Birthday problem, birthday attack, tiger hash, HMAC, CMAC
  - Digital Signatures
  - Cryptanalysis-Enigma, RC4 as used in WEP, Linear and Differential Cryptanalysis attacks on RSA
  - Security Protocols-SSH, SSL, IPSec, Kerberos, WEP, GSM
  - Firewalls

Readings:

- The course will be taught by Research Papers.

- **RCS015 - LINEAR INTEGER PROGRAMMING**
- **RCS016 - MACHINE LEARNING**
- **RCS017 - MODERN APPROACH TO ARTIFICIAL INTELLIGENCE**
- **RCS018 - NEURAL NETWORK**
- **RCS019 - PROBABILISTIC GRAPHICAL MODELS**
- **RCS020 - SCALABLE MACHINE LEARNING**
- **RCS021 - SOFTWARE QUALITY ASSURANCE**
- **RCS022 - SOFTWARE TESTING**
RCS023 - SPECIAL TOPICS IN ARTIFICIAL INTELLIGENCE (MULTI-AGENT SYSTEMS)

- **Communication**: Speech Acts, Agent Communication Languages, KIF, KQML, The FIPA Agent Communication Languages, Ontologies for Agent Communication, Coordination Languages.
- **Working Together**: Cooperative Distributed Problem Solving, Coherence and Coordination, Task Sharing and Result Sharing, Task Sharing in the Contract Net, Result Sharing, Handling Inconsistency, Coordination, Multi-agent Planning and Synchronization.

Readings:


RCS024 - SPECIAL TOPICS IN COMPUTATIONAL INTELLIGENCE

- (Rough Granular Computing)
- **Rough Sets in Approximation**: Parameterized approximation space, uncertainty function, rough inclusion function, lower and upper approximations, properties of approximations such as accuracy and quality of approximation, learning approximation space from data discretization
and approximation spaces, Distances and approximation spaces; concept approximation.

- **Data Reduction**: Reducts in the context of information systems and decision tables, significance of attributes and stability of reducts, representatives in information systems and decision tables.

- **Classification and Clustering Methods**: Information granulation, decision rules in rough set models, evaluation of decision rules, nearest neighbor algorithms; self-organizing system for information granulation, rough clustering and its evaluation.

**Readings:**


**RCS025 - SPECIAL TOPICS IN COMPUTER NETWORKS**

- Real-time and non-real-time applications: Quality of Service (QOS) requirements of real-time applications – bandwidth, delay and delay variation parameters, Quality of service metrics, guaranteed and best-effort services.

- IEEE Wireless LAN (WLAN) standard: 802.11 and 802.11e standards, WLAN services-association, disassociation, re-association, distribution, integration, authentication, de-authentication and data delivery services.

- WLAN centralized protocol functions: Point Coordination Functions (PCF), Hybrid Coordination Function (HCF), HCF Controlled Channel Access (HCCA); HCCA admission control mechanisms, HCCA parameterized QOS.

- WLAN distributed protocol functions: Distributed Coordination Functions (DCF), Enhanced Distributed Channel Access (EDCA), EDCA priority based QOS.

- Performance analysis of WLAN distributed protocol functions: Random variables and random process, Markov chain model of DCF and EDCA protocols, Throughput and delay analysis.
Readings:


➤ RCS026 - SPECIAL TOPICS IN DATA MINING

- **Classification Techniques:** Models and Patterns, Performance Measures, Forms of Knowledge, Decision Trees, Linear Regression, Neural Networks, k-Nearest Neighbors, Naïve Bayesian Classifiers, Support Vectors Machines, Ensemble Methods.
- **Clustering Techniques:** Clustering Concepts, Clustering Vs Classification, Clustering Techniques, Partitioning Methods, Comparing k-Means and k-Medoids, Expectation-Maximization, Hierarchical Methods, Density-Based Methods, Grid-Based Methods, Dealing with Large Data.
- Use of the techniques for web usage mining, user tracking and profiling, web content and structure mining, web personalization, text mining, spatial mining, bioinformatics and other scientific applications.

Readings:

RCS027 - SPECIAL TOPICS IN DATABASE SYSTEM

- Introduction to Web Data Management and XML.
- XML Query Languages: XQuery, XPath, XSLT, XSQL.
- Node and Link Objects: Representing Metadata of Web Documents and Hyperlinks, Metadata Associated with HTML and XML Documents, Representing Structure and Content of Hyperlinks, Node and Link Objects, Node and Link Structure Trees.
- Databases Modeling: Recent Approaches in Modeling Web Data, Storage of XML data in databases, publishing data from databases in XML. Use of Tools for storing and retrieving data from XML Databases.

Readings:

1. Sourav Bhowmick, Sanjay Madria, and Wee Keong Ng, Web Data Management A Warehouse Approach, Springer.

RCS028 - SPECIAL TOPICS IN INFORMATION SECURITY

- Information Hiding: Introduction, Background, and Applications of Information hiding: Data hiding, applications of data hiding.
- Fingerprinting: Introduction, Terminology and requirements, Classifications, Research history, fingerprinting schemes, Statistical fingerprinting, and Collusion-secure fingerprinting.

Readings:


RCS029 - SPECIAL TOPICS IN SOFT COMPUTING

- **Type-2 Fuzzy Sets**: Notion of uncertainty of membership in a fuzzy set, foot print of uncertainty, embedded fuzzy sets, operations on type-2 fuzzy sets, type-2 fuzzy relations, type reduction, type-2 fuzzy inference system.
- **Fuzzy Clustering**: Limitations of hard partitioning and need for fuzzy clustering, FCM, PCM, GK, and FMLE algorithms, cluster validity measures
- **Projected Clustering**: The problem of high dimensionality in clustering, use of projected clustering methods to address the problem of high dimensionality—grid based, density based, centroid based, and hierarchical approaches.
- **Rough Set Based Methods**: Information granulation using rough sets, decision rules in rough set models, classification, and clustering methods based on rough sets.
- **Neuro Fuzzy Systems**: Neuro fuzzy systems of Mamdani, logical, and Takagi-Sugeno type, flexible neuro fuzzy systems.

Readings:

1. L. Rutkowski, Computational Intelligence, Methods and Techniques, Springer, 2008.

RCS030 - SWARM INTELLIGENCE

- Introduction to Swarm Intelligence
- Particle Swarm Optimization
- Ant Colony Optimization
- Job Scheduling on Computational Grid (PSO Application)
- PSO for Data Mining
- ACO for Data Mining
- Solving the Traveling Salesman Problem using Ant Colonies
- Swarm-based Network Management
- Multi-Objective Optimization
- Swarm-Bots
Bibliography:
- Eric Bonabeau, Marco Dorigo and Guy Theraulaz, Swarm Intelligence: From Natural to Artificial Systems, Oxford University Press, 1999
- Proceedings of various recent conferences can be referred to

Readings:

1. The course will be taught by Research Papers.

- RCS031 - THEORY OF NP COMPLETENESS
  - Introduction to Theory of NP-Completeness.
  - Cook’s Theorem, CSP
  - Clique Problem.
  - Vertex Cover and Independent Set
  - Sequencing Problems: Hamiltonian cycle Problem and TSP
  - Subset-Set Problem
  - Graph Coloring
  - Scheduling Problems

Readings:

1. The course will be taught by Research Papers.