DAV UNIVERSITY JALANDHAR

FACULTY OF SCIENCE

Course Scheme and Syllabus
for

Ph. D Course Work

Computer Science & Applications

Syllabi Applicable for 2023 Batch Onwards

Total minimum credits required for Pre Ph.D. course work is 14

S.No	Paper Code	Course Title	Course Type	L	T	P	Cr
1	PHD800	Research Methodology	Core	4	0	0	4
2	PHD800A	Research and Publications Ethics	Core	2	0	0	2
	Candidate will adopt two courses from the following department electives						
3	CSA801	Digital Image Processing and Computer Vision	DSE	4	0	0	4
4	CSA802	Soft Computing	DSE	4	0	0	4
5	CSA803	Data Mining and Data Warehousing	DSE	4	0	0	4
6	CSA804	Natural Language Processing	DSE	4	0	0	4
7	CSA805	Cybersecurity	DSE	4	0	0	4
8	CSA806	Machine Learning	DSE	4	0	0	4
				14	**0**	**0**	**14**

Course Title: Research Methodology
Course Code: PHD800
Course Duration: 45-60 Hours

L	T	P	Credits
4	0	0	4

Objectives: The major objective of this course is the understanding and application of emerging trends and new skills associated with research. The course will also introduce students to the safeguards against various errors in conducting any research.

UNIT – A **13 Hours**

Introduction to Research: Meaning of Research, Objectives of Research, Types of Research, Research Approaches, Research Process. Defining the Research Problem: What is a Research Problem? Selecting the Problem, Necessity of Defining the Problem, Review of Literature. Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, and Important Concepts Relating to Research Design, Different Research Designs like various experimentation-Quasi, Latin Square, Factorial Design, their uses& methods.

UNIT-B **14 Hours**

Methods of Data Collection: Collection of Primary Data, Observation Method, Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules, Some Other Methods of Data Collection, Collection of Secondary Data, Selection of Appropriate Method for Data Collection. Measurement and Scaling: Non-comparative Scaling Techniques, Continuous Rating Scale, Itemized Rating Scale, Non-comparative Itemized Rating Scale Decisions, Multi-item Scales, Scale Evaluation, Choosing a Scaling Technique. Questionnaire & Form Design: Questionnaire & Observation Forms, Questionnaire Design Process.

UNIT – C **13 Hours**

Sampling design and Procedures: Sample or Census, The Sampling Design Process, A Classification of Sampling Techniques, Choosing Nonprobability Versus Probability Sampling, Uses of Nonprobability versus Probability Sampling. Data Preparation: Editing, Coding, Transcribing. Hypothesis Testing- T-test, Z-test, ANOVA-test, Chi-Square etc.

UNIT – D **12 Hours**

Organization of Research Report: Types, Structure, Bibliography, References & Appendices. Style Manuals: APA style, MLA style, The Chicago Manual of style etc. Evaluation of Research Report, When and where to publish, Ethical issues related to publishing, Plagiarism.

Reference Books:

1. Kumar, R. Research Methodology: A step-by-step guide for Beginners. London: SAGE, 2005.
2. Kothari, C. R. Research methodology: Methods & Techniques (Rev. Ed.) New Age International, New Delhi, 2006.
3. Malhotra, N. K. Marketing research: An applied orientation, 6th ed. Saddle River, N.J.: Pearson. Additional, 2010.

4. Dowdy, S., Wearden, S. and Chilko, D., Statistics for Research, Wiley Series (2004)

Course Title: Research and Publications Ethics
Course Code: PHD800A

L	T	P	Credits
0	0	4	2

Objectives: Focusing on basics of philosophy of science and ethics, research integrity, publication ethics. Hands on sessions are designed to identify research misconduct and predatory publications. Indexing and citation databases, open access publications, research metrics (citations, h-index, impact factor, etc.) and plagiarism tools will be introduced in this course.

UNIT – A **8 Hours**

Philosophy and Ethics

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

Scientific Conduct

1. E thics 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

UNIT-B **7 Hours**

Publication Ethics

1. Publication ethics: definition, introduction and importance
2. Best practices/standards setting initiatives and guidelines: 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

UNIT – C **8 Hours**

Open Access Publishing

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: UGC-CARE list of journals
4. Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

Publication Misconduct

1. Group discussions
2. Subject specific ethical issues, FFP, authorship
3. Conflicts of interest

4. Complaints and appeals: examples and fraud from India and abroad

UNIT – D **7 Hours**

Software tools

Use of reference management software like Mendeley, Zotero etc. and anti-plagiarism software like Turnitin, Urkund

Databases and research metrics

1. Databases (4hrs)
2. Indexing databases
3. Citation databases: Web of Science, Scopus etc.
4. Research Metrics (3hrs)
5. Impact factor of journal as per Journal Citation Report, SNIP, SJR, IPP, CiteScore
6. Metrics: h-index, g-index,i-10 index, altmetrics

Reference Books:

1. Bird, A. Philosophy of Science, 2006.
2. Mac Intyre, Alasdair. A Short History of Ethics, London, 1967.
3. Chaddah, P. Ethics in Competitive Research: Do Not get Scooped; Do Not get Plagiarized, ISBN:978-9387480865.
4. National Academy of Sciences. On Being a Scientist: A Guide to Responsible Conduct in Research: Third Edition, National Academics Press. 2009.
5. Resnik, D.B. What is ethics in research & why is it important. National Institute of Environmental Health Sciences, 1-10. 2011.
6. Bcall,J, Predatory publishers are corrupting open access, Nature, 489(7415), 179-179. 2012.
7. Indian National Science Academy, Ethics in Science Education, Research and Governanace, 2019.

Course Title: Digital Image Processing and Computer Vision
Course Code: CSA801
Course Duration: 45-60 Hours

L	T	P	Credits
4	0	0	4

Course Objective: To introduce basic image processing techniques, spatial and frequency domain, linear programming, color image processing, image compression, etc. Students will able to apply computer techniques to designing for real world applications.

Course Outcomes:

CO-1	To introduce basic image processing techniques.
CO-2	To learn image enhancement techniques in spatial and frequency domain.
CO-3	To obtain knowledge about Image restoration and compression techniques.
CO-4	Explore about Image Segmentation and Morphological Image Processing and Object Representation and description and Computer Vision Techniques

UNIT – A **10 Hours**

Introduction: Motivation & Perspective, Applications, Components of Image Processing System, Fundamentals Steps in Image Processing, Image Sampling and Quantization, Some basic relationships like Neighbours, Connectivity, Distance Measures between pixels

UNIT – B **10 Hours**

Image Enhancement in the Spatial and Frequency Domain: Image enhancement by point processing, Image enhancement by neighbourhood processing, Basic Gray Level Transformations, Histogram Processing, Enhancement Using Arithmetic and Logic operations, Zooming, Basics of Spatial Filters, Smoothening and Sharpening Spatial Filters, Combining Spatial Enhancement Methods. Introduction to Fourier Transform and the frequency Domain, Smoothing and Sharpening Frequency Domain Filters, Homomorphic Filtering

UNIT – C **13 Hours**

Image Restoration and Image Compression: Model of The Image Degradation Restoration Process, Noise Models, Restoration in the presence of Noise Only Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering, Linear Position-Invariant Degradations, Estimation of Degradation Function, Inverse filtering, Wiener filtering, Constrained Least Square Filtering, Geometric Mean Filter, Geometric Transformations. Data Redundancies, Image Compression models, Elements of Information Theory, Lossless and Lossy compression, Huffman Coding, Shanon-Fano Coding, Arithmetic Coding, Golomb Coding, LZW Coding, Run Length Coding, Loss less predictive Coding, Bit Plane Coding, Image compression standards.

UNIT-D **12 Hours**

Image Segmentation and Morphological Image Processing: Discontinuity based segmentation, similarity based segmentation, Edge linking and boundary detection, Threshold, Region based Segmentation Introduction to Morphology, Dilation,

Erosion, Some basic Morphological Algorithms
Object Representation and description and Computer Vision Techniques: Introduction to Morphology, Some basic Morphological Algorithms, Representation, Boundary Descriptors, Regional Descriptors, Chain Code, and Structural Methods. Review of Computer Vision applications; Fuzzy-Neural algorithms for computer vision applications

Reference Books:

1. Gonzalez Rafael C. and Woods Richard E., *Digital Image Processing*, New Delhi: Prentice–Hall of India.
2. Pratt William K., *Digital Image Processing: PIKS Inside* (3rd ed.), New Jersy: John Wiley & Sons, Inc.
3. Bernd Jahne, *Digital Image Processing*, (5th revised and extended edition), Springer.
4. Annadurai S. and Shanmuga lakshmi R., *Fundamentals of Digital Image Processing*, New Delhi: Pearson Education.
5. Joshi M.A., *Digital Image Processing: An Algorithmic Approach*, New Delhi: Prentice-Hall of India.
6. Sridhar, *Digital Image Processing* 2ed, Oxford University Press.

Course Title: Soft Computing
Course Code: CSA802
Course Duration: 45-60 Hours

L	T	P	Credits
4	0	0	4

Course Objective: To introduce the concepts of artificial neural networks, fuzzy sets, fuzzy logics, various search techniques, genetic algorithms, artificial applications, supervised and unsupervised learning, neuro-fuzzy systems and their applications

Course Outcomes:

CO-1	To introduce the concepts of artificial neural networks.
CO-2	To learn Fuzzy Systems and Genetic Algorithms.
CO-3	To obtain knowledge about Hybrid Systems and GA based Backpropagation Networks.
CO-4	Fuzzy Backpropagation Networks and their applications

UNIT-A **13 Hours**

Introduction: What is Soft Computing? Difference between Hard and Soft computing, Requirement of Soft computing, Major Areas of Soft Computing, Applications of Soft Computing.

Neural Networks: What is Neural Network, Learning rules and various activation functions, Single layer Perceptrons , Back Propagation networks, Architecture of Backpropagation(BP) Networks, Backpropagation Learning, Variation of Standard Back propagation Neural Network, Introduction to Associative Memory, Adaptive Resonance theory and Self Organizing Map, Recent Applications

UNIT-B **12 Hours**

Fuzzy Systems: Fuzzy Set theory, Fuzzy versus Crisp set, Fuzzy Relation, Fuzzification, Minmax Composition, Defuzzification Method, Fuzzy Logic, Fuzzy Rule based systems, Predicate logic, Fuzzy Decision Making, Fuzzy Control Systems, Fuzzy Classification

Genetic Algorithm: History of Genetic Algorithms (GA), Working Principle, Various Encoding methods, Fitness function, GA Operators- Reproduction, Crossover, Mutation, Convergence of GA, Bit wise operation in GA, Multi-level Optimization.

UNIT-C **10 Hours**

Hybrid Systems: Sequential Hybrid Systems, Auxiliary Hybrid Systems, Embedded Hybrid Systems, Neuro-Fuzzy Hybrid Systems, Neuro-Genetic Hybrid Systems, Fuzzy-Genetic Hybrid Systems.

GA based Backpropagation Networks: GA based Weight Determination, K - factor determination in Columns.

UNIT-D **10 Hours**

Fuzzy Backpropagation Networks: LR type Fuzzy numbers, Fuzzy Neuron, Fuzzy BP Architecture, Learning in Fuzzy BP, Application of Fuzzy BP Networks.

Applications: Pattern Recognitions, Image Processing, Biological Sequence

Alignment and Drug Design, Robotics and Sensors, Information Retrieval System, Share Market Analysis, Natural Language Processing

Reference Books:

1. Sivanandam S N and Deepa S N, *Principles of Soft Computing*, New Delhi: Wiley India.
2. Karray Fakhreddine O, Silva Clarence D, *Soft Computing and Intelligent System Design*, New Delhi: Pearson Edition.
3. Mitchell M., *An Introduction to Genetic Algorithms*, New Delhi: Prentice-Hall
4. Jang J.S.R., Sun C.T. and Mizutani E., *Neuro-Fuzzy and Soft Computing*, New Delhi: PHI, Pearson Education.
5. Rich Elaine and Knight Kevin, *Artificial Intelligence*, New Delhi: TMH.
6. Ross Timothy J., *Fuzzy Logic with Engineering Applications*, New Jersy: Wiley.
7. Rajasekaran S. and Pai G.A.V., *Neural Networks, Fuzzy Logic and Genetic Algorithms*, PHI.
8. Goldberg Davis E., *Genetic Algorithms, Search, Optimization and Machine Learning*, Addison Wesley.
9. Jang J.S.R., Sun C.T., Mizutani E, *Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence*, Prentice Hall.
10. Melanie Mitchell, *An Introduction to Genetic Algorithms*, London: MIT press.
11. N.P. Padhy and S.P. Simon, *Soft Computing: With Matlab Programming*, Oxford University Press.

Course Title: Data Mining and Data Warehousing
Course Code: CSA803
Course Duration: 45-60 Hours

L	T	P	Credits
4	0	0	4

Course Objective: To introduce the concepts and techniques of data mining and data warehousing, including concept, principle, architecture, design, implementation, applications of data warehousing and data mining.

Course Outcomes:

CO-1	To introduce the concepts and techniques of data mining and data warehousing
CO-2	To learn About Data Mart, data privacy & security, visual & audio Mining
CO-3	To obtain knowledge about Data Pre-processing techniques.
CO-4	To explore classification and clustering techniques.

UNIT-A **10 Hours**

Basic Systems Concepts, Differences between Operational Database system and Data Warehouse, Need of Separate Data Warehouse, Data Warehouse Models (Enterprise, Data Mart and Virtual Data Warehouse), Extraction Transformation and Loading, Metadata repository Data Warehouse Design Process, Two Tier and Three-Tier Data Warehouse Architecture, Data Warehouse Modelling (Data Cube and OLAP), Data Warehouse Implementation, From online Analytical Processing to Multidimensional Data Mining. OLAP, ROLAP, MOLAP and HOLAP, Data Warehouse Back-End Tools and Utilities, Data Cubes, Efficient Computation of Data Cubes

UNIT-B

Data Mart: Types of Data Marts, Loading a Data Mart, Metadata for a Data Mart, Monitoring requirements for a Data Mart, Security in Data Mart From Data Warehouse to Data Mining, Steps of Data Mining Process, Types of Data Mining Tasks, need of data mining, Trends and Application of Data Mining, Statistical Data Mining, Visual and Audio Data Mining, Ubiquitous and invisible Data Mining.

Privacy, Security and Social Impacts on Data Mining, Machine Learning, Information Retrieval, Business Intelligence, Major issues in Data Mining. Data Objects and Attribute Types, Statistical Description of Data, Data Visualization, Measuring Data Similarity and Dissimilarity, Data Cube Computation, General Strategies for Data Cube Computation

UNIT-C **12 Hours**

Data Pre-processing: Major Tasks in Data Pre-processing, need of data processing, Data Cleaning, Data Integration, Data Reduction, Data Transformation and Data Discretization. Outlier detection: Outliers and their Types, Challenges of Outlier Detection, Statistical Approach to Outlier Detection, Market Basket Analysis, Frequent Itemsets, Closed Itemsets and Association. Apriori Algorithm, Improving Efficiency of Apriori algorithm, From Association to Correlation Analysis.

UNIT-D **10 Hours**

Classification: General Approach to Classification, Decision Tree Induction, Bayes Classification, and Rule based Classification, Genetic Algorithm, Random forest, Support Vector Machine Rough Set Approach, Confusion Matrix, Metrics for Evaluating Classifier Performance, Cross Validation. Applications of classification. Case study of classification

Clustering: Cluster Analysis, applications of clustering, Requirement for Cluster Analysis, Partitioning Methods, Hierarchical Methods, DBSCAN, OPTICS, CLIQUE, Clustering Graph and Network Data. Case study of clustering.

Reference Books:

1. Inmon W. H., *Building the Data Warehouse*, New York: John Wiley.
2. Inmon W. H., *Data Warehousing and Knowledge Management*, ork: New YJohn Wiley.
3. Romez Elmasri, Shamkant B., Navathe, *Fundamentals of Database Systems,* New Delhi: Pearson Education.
4. Han, Kamber, Morgan Kaufmann, *Data Mining: Concepts and Techniques*, 2nd Edition, Elsevier.
5. Inmon, W.H., C. L. Gassey, *Managing the Data Warehouse*, New York: John Wiley.
6. Fayyad, Usama M., *Advances in Knowledge Discovery and Data Mining*, MIT Press.
7. Charu C. Aggarwal, *Data Mining: The Textbook*, Springer.
8. Hongbo Du, *Data Mining Techniques and Applications: An Introduction*, Cengage India.
9. Tan, Steinbach, Kumar, *Introduction to Data Mining*, Pearson India.
10. Alex Berson, Stephen Smith, *DATA WAREHOUSING, DATA MINING, & OLAP*, McGraw Hill Education
11. Prasad R.N., *Fundamentals of Business Analytics*, Wiley India, Second Edition.
12. Shroff G., *The Intelligent Web: Search, smart algorithms, and big data*, Oxford University Press.

Course Title: Natural Language Processing
Course Code: CSA804
Course Duration: 45-60 Hours

L	T	P	Credits
4	0	0	4

Course Objectives: To provide basic knowledge about Natural language processing viz. Morph, Part of speech tagging, syntactic analysis, semantic analysis etc. and using machine learning techniques for NLP.

Course Outcomes:

CO-1	To provide basic knowledge about Natural language processing like Morph, Part of speech tagging, etc.
CO-2	To learn about syntactic analysis and semantic analysis.
CO-3	To obtain knowledge about various speech processing techniques.
CO-4	To explore machine learning techniques for NLP.

UNIT – A **10 Hours**

Introduction to NLP: Definition, History, Applications, Goals. Regular Expressions and Automata, Non- Deterministic FSAs. Transducers, English Morphology, Finite-State Morphological Parsing, Tokenization, Detection and Correction of Spelling Errors, N-grams, Part-of-Speech Tagging, English Word Classes, Tagsets, Rule-Based -HMM -Transformation-Based Tagging - Evaluation and Error Analysis. Hidden Markov and Maximum Entropy Models.

UNIT-B

10 Hours

Syntax: Word Classes and Part-of Speech Tagging, Context Free Grammars for English, Parsing with Context- Free Grammars.
Word Sense Disambiguation: Selection Restriction Based Disambiguation, Robust WSD: Machine Learning,
Supervised Learning Approaches, Bootstrapping Approaches, Unsupervised Methods, Dictionary Based Approaches.

UNIT – C **15 Hours**

Speech Processing: Phonetics, Articulatory Phonetics, Phonological Categories, Acoustic Phonetics and Signals, Speech Synthesis, Text Normalization, Phonetic and Acoustic Analysis, Diphone Waveform synthesis, Evaluation-Automatic Speech Recognition, Architecture, Hidden Markov Model to Speech, MFCC vectors, Acoustic Likelihood Computation, Evaluation. Triphones, Discriminative Training, Modeling Variation. Computational Phonology, Finite-State Phonology, Computational Optimality Theory, Syllabification, Learning Phonology and Morphology

UNIT – D **10 Hours**

Introduction to various machine learning techniques used in NLP: Machine Learning in the Context of Natural Language Processing, Supervised Machine Learning for NLP, Unsupervised Machine Learning for NLP, ML vs. NLP and Using Machine Learning on Natural Language Sentences, Hybrid Machine Learning Systems for NLP.

Reference Books:

1. Grosz, B.J., Sparck Jones, K. & Webber, B.L., *Readings in natural language processing*, Los Altos, CA. Morgan Kaufmann.
2. Allen, J., *Natural Language Understanding*, Redwood City, CA: Benjamin/Cummings.
3. Bharti, Akshar, Chaitanya Vineet, Sangal Rajeev, *Natural Language Processing*, Prentice Hall.
4. Jurafsky, D. & J. Martin, *Speech and Language Processing: An Introduction to Natural Language Processing Computational Linguistics, and Speech Recognition*, Prentice Hall.
5. Alpaydin E., *Introduction to Machine Learning*, PHI.

L	T	P	Credits
4	0	0	4

Course Title: Cybersecurity
Course Code: CSA805
Course Duration: 45-60 Hours

Course Objective: To implement successful solutions to the security needs of a business through risk compliance, incident handling, integrated network solutions, and application development while maintaining an ethical profile.

Course Outcomes:

CO-1	Student should understand cyber-attack
CO-2	Types of cybercrimes
CO-3	Cyber laws and also how to protect them self and ultimately society from such attacks

15 Hours

UNIT-A

Introduction to Security: Need for security.

- Security approaches, principles of security, types of attacks.
- Digital Privacy, Online Tracking, Privacy Laws, Types of Computer Security risks (Malware, Hacking, Pharming, Phishing, Ransomware, Adware and Spyware, Trojan, Virus, Worms, WIFI Eavesdropping, Scareware, Distributed Denial-Of-Service Attack, Rootkits, Juice Jacking),

UNIT-B **12 Hours**

- Antivirus and Other Security solution, Password, Secure online browsing, Email Security, Social Engineering, Secure WIFI settings, Track yourself online, Cloud storage security, IOT security, Physical Security Threads.
- Systems Vulnerability Scanning Overview of vulnerability scanning, Open Port / Service Identification, Banner / Version Check, Traffic Probe, Vulnerability Probe, Vulnerability Examples, OpenVAS, Metasploit.

UNIT-C **10 Hours**

- Networks Vulnerability Scanning - Netcat, Socat, Understanding port and services tools-Datapipe, Fpipe, WinRelay, Network Reconnaissance-Nmap.
- Network Defense tools Firewalls and Packet Filters: Firewall Basics, Packet Filter Vs Firewall, How a Firewall Protects a Network, Packet Characteristic to Filter, Stateless Vs Stateful Firewalls, Network Address Translation (NAT) and Port Forwarding the basis of Virtual Private Networks, Linux Firewall, Window Firewall, Snort: Introduction Detection System

UNIT-D **8 Hours**

- Introduction to Cyber Crime and law Cyber Crimes, Types of Cybercrime, Hacking, Attack vectors, Cyberspace and Criminal Behavior, Clarification of Terms, Traditional Problems Associated with Computer Crime, Introduction to Incident Response, Digital Forensics, Computer Language, Network Language, Realms of the Cyber world.

Reference Books:

1. Cryptography and Network Security: Behrouz A. Forauzan 2/e
2. Cryptography and Network Security: William Stallings 4/e
3. Anti-Hacker Tool Kit (Indian Edition) by Mike Shema, Publication Mc Graw Hill.
4. Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal Perspectives by Nina Godbole and Sunit Belpure, Publication Wiley.

Course Title: Machine Learning
Course Code: CSA806
Course Duration: 45-60 Hours

L	T	P	Credits
4	0	0	4

Course Objective: The main objective of this course is to enabling the student with basic knowledge on the techniques to build an intellectual machine for making decisions behalf of humans. This course covers the techniques on how to make learning by a model, how it can be evaluated, what are all different algorithms to construct a learning model.

Course Outcomes:

CO-1	Know the basics and mathematics behind various Machine Learning algorithms.
CO-2	Think analytically and suggest possible solutions to problems using Machine Learning.
CO-3	Know various programming tools to apply Machine Learning techniques into action.

UNIT-A **15 Hours**

- Brief Introduction to Machine Learning, Supervised Learning, Unsupervised Learning
- Brief introduction to Reinforcement Learning, Probability Basics, Linear Algebra
- Statistical Decision Theory – Regression & Classification, Bias – Variance trade off

UNIT-B **12 Hours**

- Linear Regression & Gradient Descent, Multivariate Regression & Gradient Descent Dimensionality Reduction, Subset Selection, Shrinkage Methods, PCA, Principle Components Regression (PCR)
- Linear Classification, Logistic Regression & Gradient Descent, Linear Discriminant Analysis (LDA), Optimization,
- Classification -Separating Hyper planes Classification (SVM)

UNIT-C **10 Hours**

- Introduction to Artificial Neural Networks
- Early models, Back Propagation, Initialization, Training & Validation, Parameter Estimation (Maximum Likelihood Estimation, Bayesian Parameter Estimation)
- Decision Trees, Evaluation Measures, Hypothesis Testing, Introduction to Ensemble Methods

UNIT-D **8 Hours**

- Graphical Models, Clustering, Gaussian Mixture Models, Spectral Clustering
- Ensemble Methods
- Learning Theory, Reinforcement Learning

Reference Books:

1. T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e, 2020.
2. Christopher Bishop. Pattern Recognition and Machine Learning. 2e.