Structure of Post Graduate
(ME Computer Science and Engineering)

THAPAR INSTITUTE OF ENGINEERING & TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
PATIALA, PUNJAB, INDIA
COURSE SCHEME & SYLLABUS
(2019)

M.E. (COMPUTER SCIENCE & ENGINEERING)
### SEMESTER I

<table>
<thead>
<tr>
<th>S. NO.</th>
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<tr>
<td>1</td>
<td>PCL108</td>
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### SEMESTER II

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**GRAND TOTAL - FOUR SEMESTER CREDITS**

69
Course Objective: The course aims to introduce to the students, fundamental principles as well as advanced topics in statistics and sampling techniques. This course underscores the importance of statistical methods to perform scientific and engineering research.

Review of basic probability and statistical principles: Axioms of probability, conditional probability, Bayes' rule, Conditional probability distributions, conditional expectations, law of total probability and law of total expectation, introduction to Bernoulli, binomial, Poisson, geometric, Normal, exponential, distributions, joint and marginal distributions, central limit theorem, probability distribution of functions of random variables.

Hypothesis tests: Introduction to sampling distributions (standard Normal, chi-square, F and t distributions) and their properties, introduction to hypothesis tests (difference between one tailed and two tailed tests), level of significance of test and power of test, two sample test for means using t-distribution.

Analysis of variance: One Way ANOVA, two-way ANOVA with examples.


Multivariate Data Analysis and regression: Introduction to linear regression with trends and least squares estimate, definition of Covariance matrix and its application in engineering problems using Principal Component Analysis.


Laboratory Work: Each laboratory experiment will consist of numerical exercises on one of the above topics. Laboratory experiments will be performed using Matlab/SPSS.

Course Learning Outcomes (CLO): Upon the completion of this course, the students will able to:

1. compute probabilities of composite events along with an understanding of random variables and distributions.
2. obtain foundational understanding of discrete Markov processes.
3. make statistical inferences using principles of hypothesis tests and ANOVA.
4. perform analysis of time series data with different time series models.
5. perform multivariate data analysis using Principal Component Analysis and linear regression.

Recommended Books:

Course Objective: To learn the advanced concepts of data structure and their implementation. The course has the main ingredients required for a computer science graduate and has all the necessary topics for assessment of data structures.

Introduction to Basic Data Structures: Importance and need of good data structures, Arrays, Linked lists; Abstract data types and their implementation: Stacks, Queues, Heaps, Priority queues, Sets, Maps, Binary search trees, Hashing; Strategies for choosing the appropriate data structures.


Internal and External Sorting algorithms: Linear Search, Binary Search, Bubble Sort, Selection Sort, Insertion Sort, Shell Sort, Quick Sort, Heap Sort, Merge Sort, Counting Sort, Radix Sort.


Laboratory Work: To Implement in detail all the data structures and algorithms given above in a high level programming language.

Recommended Books:
Course Learning Outcomes (CLOs)

<table>
<thead>
<tr>
<th>CLO</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO1</td>
<td>Implement basic data structures and analyze them to solve fundamental problems.</td>
</tr>
<tr>
<td>CLO2</td>
<td>Implement different tree data structures and differentiate among them with respect to their applications.</td>
</tr>
<tr>
<td>CLO3</td>
<td>Identify properties of graphs and employ them to model a variety of real-world problems.</td>
</tr>
<tr>
<td>CLO4</td>
<td>Demonstrate the usage of several string matching algorithms and associated data structures.</td>
</tr>
<tr>
<td>CLO5</td>
<td>Analyse, evaluate and choose appropriate data structure to solve real-world problems.</td>
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Student Outcomes (SOs)

<table>
<thead>
<tr>
<th>SO</th>
<th>Description</th>
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<tbody>
<tr>
<td>A2</td>
<td>Applying basic principles of science towards solving engineering problems.</td>
</tr>
<tr>
<td>A3</td>
<td>Applying engineering techniques for solving computing problems.</td>
</tr>
<tr>
<td>B1</td>
<td>Identify the constraints, assumptions and models for the problems</td>
</tr>
<tr>
<td>B2</td>
<td>Use appropriate methods, tools and techniques for data collection.</td>
</tr>
<tr>
<td>E1</td>
<td>Identify engineering problems.</td>
</tr>
<tr>
<td>E3</td>
<td>Use analytical and computational methods to obtain solutions.</td>
</tr>
<tr>
<td>H1</td>
<td>Aware of environmental and societal impact of engineering solutions.</td>
</tr>
<tr>
<td>I2</td>
<td>Recognize the importance of life-long learning.</td>
</tr>
<tr>
<td>J1</td>
<td>Comprehend the importance of contemporary issues.</td>
</tr>
<tr>
<td>K2</td>
<td>Apply different data structures and algorithmic techniques.</td>
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</table>
Fundamental Algorithm Paradigms: Divide-and-Conquer, Dynamic Programming, Greedy, Branch-and-Bound, Backtracking; Illustrations of these techniques for Problem-Solving: Bin Packing, Knap Sack, TSP; Amortized Analysis.

Graph Algorithms: Traversal algorithms: Depth First Search (DFS) and Breadth First Search (BFS); Shortest path algorithms, Transitive closure, Minimum Spanning Tree, Topological sorting, Flow Network.

Numerical algorithms: Integer, Matrix and Polynomial Multiplication, FFT, Extended Euclid's algorithm, Modular Exponentiation, Primality Testing, Cryptographic Computations.

Geometric algorithms: range searching, convex hulls, segment intersections, closest pairs


Approximation algorithms: Need of approximation algorithms: Introduction to P, NP, NP-Hard and NP-Complete; Deterministic, Non-Deterministic Polynomial time algorithms; Knapsack, TSP, Set Cover, Open Problems.

Randomized algorithms: Introduction, Type of Randomized Algorithms, Quick Sort, Min- Cut, 2-SAT; Game Theoretic Techniques, Random Walks.

Laboratory Work: To design and implement algorithms for problems given above in a high level programming language.

Recommended Books:

Course Learning Outcomes (CLOs):
1. To learn the appropriate algorithmic approach to a problem.
2. Demonstrate the ability to evaluate algorithms, to provide justification for that selection, and to implement the algorithm in a particular context.
3. Employ graphs to model a variety of real-world problems, synthesise tree and graph algorithms and analyze them.
4. Implement advanced algorithmic techniques such as String Matching Algorithms, Approximation algorithms etc.
Course Objective: The course aims to shape the attitudes of learners regarding the field of linear algebra and random process. Specifically, the course aims to (i) develop maturity in linear algebraic structure that appear in various areas of computer science (ii) motivate students towards an intrinsic interest in statistical thinking (iii) instil the belief that statistics is important for scientific research.

Linear Algebra

Matrices: Matrix multiplication, Transposes, Inverses, Gaussian elimination, factorization $A = LU$, rank of matrix.

Vector Spaces: Column ad row spaces, Solving $AX = 0$ and $AX = B$. Linear Independence/Dependence, Basis, Dimension and Linear Transformation.

Orthogonality: Orthogonal Vectors and subspaces, projection, and least squares, Gram – Schmidt orthogonalization.


Random Processes

Basic topics: Event, Probability, Conditional probability, Independence, Product spaces

Random Variables: Distributions, Laws of average, discrete and continuous random variables, random vectors, Monte Carlo simulation.

Discrete Random Variables: Probability mass function, Independence, Expectation, Sums of random variables.

Continuous Random Variables: Probability density function, Independence, Expectation, Conditional expectations, Functions of random variables, Sums of random variables, Multivariate normal distributions.

Course Learning Outcomes (CLO): Upon successful completion of the course, the students will be able to

- Identify and comprehend linear algebraic structures that appear in computer science.
- Use linear algebraic methods to perform computational task.
- Apply properties of eigenvalues and orthogonality to analyse computational problems occurring in various areas of computer science.
- Understand and apply various concepts of probability theory.
- Comprehend and apply the properties of random processes in real life problems.

Recommended Books:
Course Objectives: This course provides an advanced level of understanding to machine learning and statistical pattern recognition. It offers some of the most cost-effective approaches to automated knowledge acquisition in emerging data-rich disciplines and focuses on the theoretical understanding of these methods, as well as their computational implications.


Decision Tree Learning: Decision tree representation, appropriate problems for decision tree learning, Univariate Trees (Classification and Regression), Multivariate Trees, Basic Decision Tree Learning algorithms, Hypothesis space search in decision tree learning, Inductive bias in decision tree learning, Issues in decision tree learning.

Bayesian Learning: Bayes theorem and concept learning, Bayes optimal classifier, Gibbs algorithms, Naive Bayes Classifier, Bayesian belief networks, The EM algorithm.

Artificial Neural Network: Neural network representation, Neural Networks as a paradigm for parallel processing, Linear discrimination, Pairwise separation, Gradient Descent, Logistic discrimination, Perceptron, Training a perceptron, Multilayer perceptron, Back propagation Algorithm. Recurrent Networks, Dynamically modifying network structure.

Genetic Algorithms: Basic concepts, Hypothesis space search, Genetic programming, Models of evolution and learning, Parallelizing Genetic Algorithms.

Data Mining Techniques for Analysis: Classification: Decision tree induction, Bayes classification, Rule-based classification, Support Vector Machines, Classification Using Frequent Patterns, k-Nearest-Neighbor, Fuzzy-set approach Classifier, Clustering:K-Means, k-Medoids, Agglomerative versus Divisive Hierarchical Clustering Distance Measures in Algorithmic Methods, Mean-shift Clustering

Laboratory Work: It is concerned with the design, analysis, implementation, and applications of programs that learn from experience. Learning algorithms can also be used to model aspects of human and animal learning.

Recommended Books
COURSE LEARNING OUTCOMES (CLOs)

Students will able to:

<table>
<thead>
<tr>
<th>CLO</th>
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<tbody>
<tr>
<td>CLO1</td>
<td>Demonstrate in-depth knowledge of methods and theories in the field of machine learning. To provide an introduction to the basic principles, techniques, and applications of Machine Learning, Classification Tasks, Decision tree learning.</td>
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<tr>
<td>CLO2</td>
<td>Understand and use Bayesian perspective on machine learning, Artificial neural networks, back propagation algorithm</td>
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<tr>
<td>CLO3</td>
<td>Assess learning algorithms modelled after biological evolution, including genetic algorithms and genetic programming.</td>
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<tr>
<td>CLO4</td>
<td>Assess explanation-based learning that uses prior knowledge to explain observed training examples, then generalizes based on these explanations and discuss approaches to combining approximate prior knowledge with available training data in order to improve the accuracy of learned hypotheses.</td>
</tr>
<tr>
<td>CLO5</td>
<td>Demonstrate knowledge of the disciplinary foundation and of proven experience in the design and analysis of learning algorithms and systems. To demonstrate the ability to critically evaluate and compare different learning models and learning algorithms and be able to adapt or combine some of the key elements of existing machine learning algorithms to design new algorithms as needed.</td>
</tr>
</tbody>
</table>

Unit 2 Statistical Inference: Concept of standard error and its uses. The significances of statistical measures, Test of the significance difference between two means: Z-Test, T-Test, Analysis of variance and analysis of covariance: Assumptions of ANOVA, one way ANOVA, two way ANOVA. Post Hoc tests: Duncan’s multiple range test, Tukey’s test. Non-parametric tests: chi-square test, medium test, Friedman test, Wilcoxon test, Nemenyi test.

Unit 3 Regression: The Simple Regression Model, Multiple Regression Analysis: Estimation, Multiple Regression Analysis: Inference, Multiple Regression Analysis: OLS Asymptotics..Multiple Regression Analysis with Qualitative Information: Binary (or Dummy) Variables. Heteroskedasticity.

Unit 4 Ethics: Values, Morals and Ethics; Need for Ethics in Professional Life; Kohlberg’s Theory of Moral Development and Its Applicability to Engineers. Professional Ethics: Values in Work Life; Professional Ethics and Ethos; Codes of Conduct, Whistle-Blowing, Corporate Social Responsibility, Case Studies on Ethics in Business.


Text Books:

Cryptography: Traditional and Modern Cryptography techniques. Symmetric key cryptography, Asymmetric key cryptography (ECC and RSA), Signatures, hash.

Blockchain definition, shortcomings of current transaction systems, distributed network, difference between blockchain and traditional database, evaluation of blockchain. Core Components of Blockchain Architecture, Bitcoin’s block structure, node, Merkle Trees, Shared ledger, Mining, validators.

Consensus and cryptography behind the blockchain: Bitcoin Blockchain transaction flow. Blockchain need, use cases of blockchain, Types of Blockchain Architecture (public, private, consortium).

How consensus works? Consensus in Bitcoin – I (The Basics, PoW and Beyond, The Miners), Permissioned Blockchain, proof of stake, delegated proof of stake, round robin, PBFT, POET.


**Laboratory Work:** To design and implement algorithms on the above topics. Laboratory experiments will be performed using different blockchain tools: remix, geth and mist etc.

**Recommended Books:**

- Blockchain quick reference, by Brenn Hill, Packt Publishing; 1 edition (August 10, 2018),

**Course Learning Outcomes (CLOs):**

1. Understand the basic concept of modern and traditional cryptography techniques.

2. Comprehend the concept of Blockchain Architecture (public, private, consortium).

3. Demonstrate the Ethereum, Ethereum network, and Bitcoin’s block structure.


5. Demonstrate Hyperledger fabric and Hyperledger suitability for project development.
**Course Objectives:** This course will introduce the concepts, techniques, design and applications of data warehousing and data mining. The course is expected to enable students to understand and implement classical algorithms in data mining and data warehousing.

**Data Mining fundamentals.** Data mining, Data Mining Functionalities, Classification of Data Mining systems, Major issues in Data Mining, Data object & attribute types.

**Data Pre-processing:** Need of Pre-processing the Data, Data Cleaning, Data Integration, Data Reduction, Data Discretization.

**Data Warehousing:** Introduction, Operational Data stores, ETL, Data Warehouses, Data Warehouse design & usage, Data Warehouse Metadata, Data Warehouse modeling-OLAP, Characteristics of OLAP systems, Multidimensional view and data cube, Data cube operations.

**Mining frequent patterns and associations:** Introduction, Association rules mining, Naive algorithm, Apriori algorithm, Apriori TID, Direct hashing and pruning (DHP), Dynamic Item set counting (DIC), Mining frequent pattern without candidate generation.

**Classification:** Introduction, Decision Tree Induction– split algorithm based on information theory, split algorithm based on Gini index, Bayes Classification Method, Rule Based classification, Model Evaluation & Selection.


**Web data mining:** Web Terminology and Characteristics, Locality and Hierarchy in the web, Web Content Mining, Web Usage Mining, Web Structure Mining.

**Laboratory Work:** The lab will cover data mining techniques-classification, clustering, and association rule mining and Data warehousing.

**Recommended Books:**
On completion of this course, students will be able to

<table>
<thead>
<tr>
<th>CLO1</th>
<th>Comprehend the concepts of data mining, data preprocessing techniques and Data warehouses.</th>
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<tbody>
<tr>
<td>CLO2</td>
<td>Understand and apply frequent pattern mining techniques for market basket analysis.</td>
</tr>
<tr>
<td>CLO3</td>
<td>Perform classification of data by using decision tree, split algorithm based on information theory, Gini index and Naïve Bayes.</td>
</tr>
<tr>
<td>CLO4</td>
<td>Demonstrate clustering of data by using partitioned methods, hierarchical methods density based methods and Grid based methods.</td>
</tr>
<tr>
<td>CLO5</td>
<td>Comprehend the techniques and use of web data mining.</td>
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</table>

**Course Objectives**: To have an advanced level of understanding of common and emerging methods of organizing, summarizing, and analyzing large collections of unstructured and lightly-structured text.


**Informational Retrieval**: Query processing models. Probabilistic models (Binary independence model, Robertson/Spark Jones weighting formula, Two-Poisson model), Relevance feedback (Term selection, Pseudo relevance feedback); Language models: Unigram, Bigram language models, Generating queries from documents, Language models and smoothing, Ranking with language models, Kullback Leibler divergence, Divergence from randomness, Passage retrieval and ranking.


**Types of information retrieval systems**: Web retrieval and mining, Semantic web, XML information retrieval, Recommender systems and expert locators, Knowledge management systems, Decision support systems, Geographic information system(GIS). Indexing: Inverted indices, Index components and Index life cycle, Interleaving Dictionary and Postings lists, Index construction, Query processing for ranked retrieval, Compression: General-purpose data compression, Symbol-wise data compression, Compressing posting lists, Compressing the dictionary.

**Recommender Systems**: Collaborative filtering and content-based recommendation of documents and products.

**Information categorization and filtering**: Classification, Probabilistic classifiers, linear classifiers, Similarity-based classifiers, Multi category ranking and classification, learning to rank, Introduction to the clustering problem, Partitioning methods, Clustering versus classification, Reduced dimensionality/spectral methods.

**Sentiment Analysis**: Introduction to sentiment analysis, Document-level sentiment analysis, Sentence-level sentiment analysis, Aspect-based sentiment analysis, Comparative sentiment analysis, baseline algorithm, Lexicons, Corpora, Tools of Sentiment analysis, Applications.

**Web Search**: Search engines; spidering; metacrawlers; directed spidering; link analysis (e.g. hubs and authorities, Google PageRank); shopping agents.

**Laboratory Work**: In Laboratory Assignments students can learn search engines and common open-source software to perform common methods of exploratory and predictive analysis and apply text analysis techniques discussed in class to solve problems of data analysis.
**Recommended Books**

Course objective: There have been many recent advances in the field of deep learning. The objective of the course is to provide exposure to these advances and facilitate in-depth discussion on chosen topics.

Machine Learning Basics: Learning, Underfitting, Overfitting, Estimators, Bias, Variance, Maximum Likelihood Estimation, Bayesian Statistics, Supervised Learning, Unsupervised Learning and Stochastic Gradient Decent

Feedforward neural network: Artificial Neural Network, activation function, multi-layer neural network.

Training Neural Network: Risk minimization, loss function, backpropagation, regularization, model selection, and optimization.

Conditional Random Fields: Linear chain, partition function, Markov network, Belief propagation, Training CRFs, Hidden Markov Model, Entropy.


Probabilistic Neural Network: Hopfield Net, Boltzman machine, RBMs, Sigmoid net, Autoencoders.

Text Books:
# Course Objective
To have an advanced level of understanding of most recent advancements in Big Data and using insights, statistical models, visualization techniques for its effective application in Business intelligence.

## Introduction to Data Analytics
- Data and Relations
- Data Visualization
- Correlation
- Regression
- Forecasting
- Classification
- Clustering

## Big Data Technology Landscape
- Fundamentals of Big Data Types
- Big data Technology Components
- Big Data Architecture
- Big Data Warehouses
- Functional vs. Procedural Programming Models for Big Data

## Introduction to Business Intelligence
- Business View of IT Applications
- Digital Data
- OLTP vs. OLAP
- BI Concepts
- BI Roles and Responsibilities
- BI Framework and components
- BI Project Life Cycle
- Business Intelligence vs. Business Analytics


## Business implementation of Big Data
- Big Data Implementation
- Big Data workflow
- Operational Databases
- Graph Databases in a Big Data Environment
- Real-Time Data Streams and Complex Event Processing
- Applying Big Data in a business scenario
- Security and Governance for Big Data
- Big Data on Cloud
- Best practices in Big Data implementation
- Latest trends in Big Data
- Latest trends in Big Data
- Big Data Computation
- More on Big Data Storage
- Big Data Computational Limitations

## Laboratory Work
- Introduction, use and assessment of most recent advancements in Big Data technology along with their usage and implementation with relevant tools and technologies.

## Recommended books:
## Course Learning Outcomes (CLOs)

<table>
<thead>
<tr>
<th>CLO</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO1</td>
<td>To comprehend the concepts of big data, architecture and environment, digital data types, structure and its implementation.</td>
</tr>
<tr>
<td>CLO2</td>
<td>Explore the advanced level of understanding of the usage of Big Data in present World.</td>
</tr>
<tr>
<td>CLO3</td>
<td>To comprehend the concepts of Map-Reduce, HDFS command and Hadoop services and its implementation.</td>
</tr>
<tr>
<td>CLO4</td>
<td>Analyze big data, create statistical models, and identify insights that can lead to actionable results</td>
</tr>
<tr>
<td>CLO5</td>
<td>To Use software tools such as R and Hadoop, in text analytics.</td>
</tr>
</tbody>
</table>
Course Objective: To develop state-of-the-art recommender systems that automate a variety of choice-making strategies with the goal of providing affordable, personal, and high-quality recommendations

Introduction: Recommender system functions, Linear Algebra notation: Matrix addition, Multiplication, transposition, and inverses; covariance matrices, Understanding ratings, Applications of recommendation systems, Issues with recommender system.

Content-based Recommendation: High level architecture of content-based systems, Advantages and drawbacks of content based filtering, Item profiles, Discovering features of documents, Obtaining item features from tags, Representing item profiles, Methods for learning user profiles, Similarity based retrieval, Classification algorithms.

Collaborative Filtering: User-based nearest neighbor recommendation, Item-based nearest neighbor recommendation, Model based and pre-processing based approaches, Attacks on collaborative recommender systems.

Knowledge based Recommendation: Knowledge representation and reasoning, Constraint based recommenders, Case based recommenders.

Ensemble-Based and Hybrid approaches: Opportunities for hybridization, Ensemble Methods from the Classification Perspective, Different types of Hybrids, Monolithic hybridization design, Parallelized hybridization design, Pipelined hybridization design, Limitations of hybridization strategies.


Laboratory Work: To implement algorithms and techniques given above using relevant tools or high level language. To design recommendation system for a particular application domain.

Recommended Books:

Course Learning Outcomes (CLOs)

<table>
<thead>
<tr>
<th>CLO</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO1</td>
<td>To comprehend the design of recommender systems: the underlying concepts, design space, and tradeoffs.</td>
</tr>
<tr>
<td>CLO2</td>
<td>To analyze the recommender systems based on collaborative filtering methods,</td>
</tr>
<tr>
<td>CLO3</td>
<td>Explore construction and implementation of a hybrid recommender system.</td>
</tr>
<tr>
<td>------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>CLO4</td>
<td>Evaluate the quality of recommendation systems through various evaluation parameters.</td>
</tr>
<tr>
<td>CLO5</td>
<td>Compare the user and community behaviour of recommendation systems and its implementation.</td>
</tr>
</tbody>
</table>
Course Objectives: To understand the advanced concepts of Natural Language Processing and to be able to apply the various concepts of NLP in other application areas.

Introduction: Origin of Natural Language Processing (NLP), Challenges of NLP, NLP Applications, Processing Indian Languages.

Words and Word Forms: Morphology fundamentals; Morphological Diversity of Indian Languages; Morphology Paradigms; Finite State Machine Based Morphology; Automatic Morphology Learning; Shallow Parsing; Named Entities; Maximum Entropy Models; Random Fields, Scope Ambiguity and Attachment Ambiguity resolution.


Meaning: Lexical Knowledge Networks, WorldNet Theory; Indian Language Word Nets and Multilingual Dictionaries; Semantic Roles; Word Sense Disambiguation; WSD and Multilinguality; Metaphors.

Speech Recognition: Signal processing and analysis method, Articulation and acoustics, Phonology and phonetic transcription, Word Boundary Detection, Argmax based computations, HMM and Speech Recognition.

Other Applications: Sentiment Analysis; Text Entailment; Question Answering in Multilingual Setting; NLP in Information Retrieval, Cross-Lingual IR.

Laboratory Work: To implement Natural language concepts and computational linguistics concepts using popular tools and technologies. To implement key algorithms used in Natural Language Processing.

Recommended Books:
# Course Learning Outcomes (CLOs)

<table>
<thead>
<tr>
<th>CLO</th>
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</tr>
</thead>
<tbody>
<tr>
<td>CLO1</td>
<td>To comprehend the concept of Natural Language Processing (NLP), its challenges and applications.</td>
</tr>
<tr>
<td>CLO2</td>
<td>To process words and word forms of the language by considering its morphology, paradigms and named entities.</td>
</tr>
<tr>
<td>CLO3</td>
<td>To demonstrate and implement the use of machine translation by using rule-based MT, Knowledge Based MT and Statistical Machine Translation etc.</td>
</tr>
<tr>
<td>CLO4</td>
<td>To comprehend the concepts of WorldNet, Semantic Roles and Word Sense Disambiguation</td>
</tr>
<tr>
<td>CLO5</td>
<td>To demonstrate the use of NLP in speech recognition and other emerging applications like Sentiment Analysis, Information Retrieval etc.</td>
</tr>
</tbody>
</table>
Course Objective: To learn the advanced concepts of cloud infrastructure and services and its implementation for assessment of understanding the course by the students.


Data Center and Warehousing: Classic Data Center, Warehousing, Virtualized Data Center (Compute, Storage, Networking and Application), Design Principles.


Virtualization: Virtualization, Advantages and Disadvantages, Types of Virtualization: Resource Virtualization i.e. Server, Storage and Network virtualization, Migration of processes, VMware cloud – IaaS.

Cloud based Data Storage: Introduction to Hadoop and Map Reduce for Simplified data processing on Large clusters, Distributed File system, Data Replication, Shared access to data stores, introduction to Python, Design of data applications based on Map Reduce, Task Partitioning, Data partitioning, Data Synchronization.

Laboratory Work: To implement Cloud, Apache and Hadoop framework and related services. To understand various concepts practically about virtualization, data storage. To implement few algorithms with the help of MapReduce and some high level language.

Recommended Books:
<table>
<thead>
<tr>
<th>CLO1</th>
<th>Understand the existing hosting platforms and computing paradigms currently being used in industry and academia.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO2</td>
<td>Comprehend data centre needs, its virtualization techniques and types of clouds.</td>
</tr>
<tr>
<td>CLO3</td>
<td>Apply virtualization in Amazon Web Services, Azure, Aneka etc.</td>
</tr>
<tr>
<td>CLO4</td>
<td>Learn to use cloud based data storage.</td>
</tr>
<tr>
<td>CLO5</td>
<td>Learn Hadoop file system and MapReduce Programing.</td>
</tr>
</tbody>
</table>
Course Objectives: To learn the fundamental aspects of computer architecture design and analysis, with a focus on processor design, pipelining, superscalar, out-of-order execution, caches (memory hierarchies), virtual memory, storage systems, and simulation technique.

Introduction To Parallel Processing: Instruction set architecture, RISC-CISC, single cycle processors, hardwired and micro-coded FSM processors, Parallelism in uniprocessor system, uniprocessor architecture, balancing of sub system bandwidth, multiprogramming and time sharing, parallel computer structures, pipeline computers, array computers, multiprocessor systems, dataflow computer concept, architectural classification scheme: multiplicity of instruction-data streams, parallelism versus pipelining, parallel processing applications, productive modeling simulation, engineering design and automation.

Principles of Pipelining and Vector Processing: Pipelining- an overlapped parallelism, multi-core processors, clock period, efficiency, throughput, classification of pipeline processors, general pipeline and reservation tables, detecting and resolving structural, data, control and name hazards; analyzing processor performance, pipeline efficiency, linear pipelining; Instruction level parallelism and instruction pipelines.

Principles of Designing Pipeline Processors: Effect of branching, data buffering and bussing structures, internal forwarding and register tagging, job sequencing and collision prevention, reservation and latency analysis, collision free scheduling, state diagram, greedy cycle, pipeline schedule optimization, Arithmetic pipelines; Pipeline control methods; and pipeline chaining, Loop unrolling, software pipelining and trace scheduling techniques for exposing instruction level parallelism, Dynamic scheduling algorithms, exploiting ILP using static scheduling and dynamic scheduling, hardware based speculation, multiple issues, and speculation.

Structure And Algorithm for Array Processors: SIMD array processor, SIMD computer organization, inter –PE communication, SIMD interconnection network, static versus dynamic networks, cube interconnection network, shuffle-exchange omega networks, parallel algorithms and SIMD matrix multiplication, Vector processing characteristics and requirements, pipelined vector processing, vectorization methods, examples of vector processing, Array processing, communication between PEs, SIMD interconnection networks, algorithms for array processing, Data and control parallelism, concurrency, scalability, speedup and Amdahl’s law, PRAM model of parallel computation.

Multiprocessor Architecture And Scheduling: Functional structure, loosely coupled and tightly coupled multiprocessor, deterministic scheduling strategy, deterministic scheduling model, control flow versus data flow computer, data flow graphs and languages, memory technology; memory addressing modes, direct-mapped, associative cache; write through and write-back caches; single-cycle, pipelined cache; analyzing memory performance, memory Hierarchy, Cache design issues, Virtual memory addressing, memory protection mechanisms, Multiprocessor memory architecture, Multi Core Architectures, Multiprocessors and multi-computers; Processor organizations: mesh, binary tree, hypercube; Shared memory and message passing systems; Mapping and Scheduling: Embedding of task graphs in processor graphs, dilation and loading, load balancing, models for static and dynamic scheduling, Using MPI and Open MP

Recommended Books
1. Kai Hwang, Computer Architecture, TMH
2. Richard Y. Kain, Advanced computer architecture: a systems design, PHI
4. Quinn, “Parallel Programming in C with MPI and Open MP”, TMH

Course Learning Outcomes (CLOs)

<table>
<thead>
<tr>
<th>CLO 1</th>
<th>Understand different processor architectures, system-level design processes, components and operation of a memory hierarchy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO 2</td>
<td>Get an insight into how applications and performance issues influence a range of design choices of computer-based systems</td>
</tr>
<tr>
<td>CLO 3</td>
<td>Develop system’s programming skills in the context of computer system design and organization</td>
</tr>
<tr>
<td>CLO 4</td>
<td>Able to understand the principles of I/O in computer systems, including viable mechanisms for I/O and secondary storage organization</td>
</tr>
</tbody>
</table>
Course Objectives: This course is designed to provide hands-on experience in different computer forensics situations that are applicable to the real world. This course will provide theoretical and practical knowledge on ethical hacking and digital forensics to investigate, detect and prevent digital crimes.


Acquisition and Duplication: Sterilizing Evidence Media, Acquiring Forensics Images, Acquiring Live Volatile Data, Data Analysis, Metadata Extraction, File System Analysis, Performing Searches, Recovering Deleted, Encrypted, and Hidden files, Internet Forensics, Reconstructing Past Internet Activities and Events, E-mail Analysis, Messenger Analysis

Reconnaissance and Scanning: Information Gathering Methodology, Locate the Network Range, Active and Passive reconnaissance, Scanning, Elaboration phase, active scanning using various tools, Enumeration, Detecting live systems on the network, Discovering services running/listening on target systems, Understanding port scanning techniques, Identifying TCP and UDP services running on the network

Session Hijacking: Understanding Session Hijacking, Phases involved in Session Hijacking, Types of Session Hijacking, and Session Hijacking Tools.


Laboratory work: Lab Exercises include forensic investigation tools (from Item confiscated to submitting evidence for lawful action), such as FTK, Sleuth Toolkit (TSK), Autopsy, etc.
Scanning tools like IPEYE, IPsecScan, SuperScan etc. and Hacking Tools likes Trinoo, TFN2K, Zombic, Zapper etc.

Recommended Books
Course Learning Outcomes (CLOs)

<table>
<thead>
<tr>
<th>CLO</th>
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</tr>
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<tbody>
<tr>
<td>CLO1</td>
<td>Analyze &amp; demonstrate the crime scene and criminology.</td>
</tr>
<tr>
<td>CLO2</td>
<td>Apply digital forensic tools to discover, collect, preserve and analyze digital evidence.</td>
</tr>
<tr>
<td>CLO3</td>
<td>Exploit the vulnerabilities related to computer system and networks.</td>
</tr>
<tr>
<td>CLO4</td>
<td>Apply techniques of system hacking and hacking over a wireless network.</td>
</tr>
</tbody>
</table>
PCS242 DIGITAL WATERMARKING AND STEGANOGRAPHY
(L: T: P :: 3: 0: 2)

Unit 1: Introduction to Digital Image Watermarking, Applications, History, Classifications based of visibility, Classification based on resistance against attacks, Classification based on embedding and extraction of watermark, Properties of watermarks, Models of Watermarking, Attacks, Watermarking domains, Measure of evaluations

Unit 2: Introduction to Fragile watermark, Types and applications, Bit plane slicing, Generation of fragile watermark, Image and LSB based approach, Hash function, self embedding techniques, embedding of fragile watermark, Extraction of fragile watermark, Tamper detection, Content authentication, Fragile watermarks with recovery capabilities, embedding in spatial domain, embedding in frequency domain, semi-fragile watermarking.

Unit 3: Introduction to Robust watermarking, Robustness of the watermark, Types and Applications, Single vs multiple robust watermark, Encrypted robust watermark, Ownership assertion using robust watermark, Objective evaluation parameters, Subjective evaluation parameters, Duel watermarking, Types and applications, embedding sequence for dual watermarks, Authentication and authorization, Dual watermark with recovery capabilities. Tamper detection and recovery.


Unit 5: Introduction to Steganalysis, scenario, Types of steganalysis, Detection, Forensic steganalysis, The influence of the cover work, LSB Based steganalysis, Visual cryptography, Hybrid approach of various image based security techniques, Audio and video watermarking and steganography, 3D watermarking, 3D steganography.

Text Books (author, title, publisher and year):
- I.J. Cox, Digital Watermarking and steganography, Morgan Kaufmann 2nd edition

After the completion of the course the student will be able to:
- Understand the fundamentals of digital image watermarking, its types and applications.
- Distinguish the concepts of fragile, robust, semi fragile and dual watermarking approaches.
- Understand the fundamentals of steganography and steganalysis, their types and applications.
- Deploy the concepts Image based steganography and watermarking on other multimedia objects like audio, video, 3D models etc.
• Develop recoverable fragile watermark, Robust watermark, Dual watermarks and hybrid approaches of all image based security techniques in spatial and frequency domain of images.
### Course Objective
This course aims to provide an understanding of the various security attacks and knowledge to recognize and remove common coding errors that lead to vulnerabilities. It gives an outline of the techniques for developing a secure application.

### Introduction

### Proactive Security development process
Secure Software Development Cycle (S-SDLC), Security issues while writing SRS, Design phase security, Development Phase, Test Phase, Maintenance Phase, Writing Secure Code – Best Practices SD3 (Secure by design, default and deployment), Security principles and Secure Product Development Timeline.

### Threat modelling process and its benefits

### Secure Coding Techniques

### Database and Web-specific issues
SQL Injection Techniques and Remedies, Race conditions, Time of Check Versus Time of Use and its protection mechanisms. Validating Input and Interprocess Communication, Securing Signal Handlers and File Operations. XSS scripting attack and its types – Persistent and Non persistent attack XSS Countermeasures and Bypassing the XSS Filters.

### Testing Secure Applications

### Laboratory work
consists of using network monitoring tools, implementing different types of attacks and some protection schemes.

### Recommended Books
## Course Learning Outcomes (CLOs)

<table>
<thead>
<tr>
<th>CLO</th>
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</tr>
</thead>
<tbody>
<tr>
<td>CLO1</td>
<td>To implement security as a culture and show mistakes that make applications vulnerable to attacks.</td>
</tr>
<tr>
<td>CLO2</td>
<td>To analyze various attacks like DoS, buffer overflow, web specific, database specific, web-spoofing attacks.</td>
</tr>
<tr>
<td>CLO3</td>
<td>To demonstrate skills needed to deal with common programming errors that lead to most security problems and to learn how to develop secure applications.</td>
</tr>
<tr>
<td>CLO4</td>
<td>To identify the nature of the threats to software and incorporate secure coding practices throughout the planning and development of the product.</td>
</tr>
<tr>
<td>CLO5</td>
<td>To properly handle application faults, implement secure authentication, authorization and data validation controls used to prevent common vulnerabilities.</td>
</tr>
</tbody>
</table>
Course Objectives: This course is designed to impart a critical theoretical and detailed practical knowledge of a range of computer network security technologies as well as network security tools and services related to ethical hacking.


Reconnaissance: Information Gathering Methodology, Locate the Network Range, Active and Passive reconnaissance

Scanning: Scanning, Elaboration phase, active scanning, scanning tools NMAP, hping2. Enumeration, DNS Zone transfer. Detecting live systems on the network, Discovering services running /listening on target systems, Understanding scanning techniques, Identifying TCP and UDP services running on the network, Active and passive fingerprinting

Trojans and Backdoors: Effect on Business, Trojan, Overt and Covert Channels, Working of Trojans, Different Types of Trojans, Different ways a Trojan can get into a system, Indications of a Trojan Attack, Some famous Trojans and ports used by them


Session Hijacking: Understanding Session Hijacking, Spoofing vs Hijacking, Steps in Session Hijacking, Types of Session Hijacking, TCP Concepts 3 Way and shake, Sequence numbers


Laboratory work: deals with launching different types of attacks and creating a network blueprint of an organization.

Recommended Books
<table>
<thead>
<tr>
<th>CLO</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO1</td>
<td>Demonstrate knowledge of various vulnerabilities in network applications.</td>
</tr>
<tr>
<td>CLO2</td>
<td>Practice awareness of various malicious content and guiding ways for protection against the same.</td>
</tr>
<tr>
<td>CLO3</td>
<td>Demonstrate knowledge of various forms of attacks.</td>
</tr>
<tr>
<td>CLO4</td>
<td>Recall judicious and ethical use of various tools.</td>
</tr>
<tr>
<td>CLO5</td>
<td>Expertise in the techniques of system hacking and hacking over a wireless network.</td>
</tr>
</tbody>
</table>
Introduction to Distributed Database: Overview, Distributed DBMS, homogenous and heterogenous DDBMS, Parallel database and its comparison with distributed database, advantages and disadvantages of distributed database, data fragmentation, data replication, introduction to distributed transaction management, distribution concurrency control and distributed recovery, architecture of DDBMS.

Distributed and Parallel Database Design: Data fragmentation, allocation, combined and adaptive approaches to database design, data directory.

Distributed Data Control and Query Processing: Concept of views and view management, access control, integrity control, query processing problem, layers of query processing, query processing and optimization in distributed systems.

Distributed Transaction Processing and Concurrency Control: Transaction concept, ACID property, Objectives of transaction management, Types of transactions, Objectives of Distributed Concurrency Control, Concurrency Control anomalies, Distributed concurrency control algorithms, distributed reliability.


Laboratory Work: To implement various concepts of distributed database studied during course.

Course Learning Outcomes: After the completion of course, students will be able to
1. understand the different architectures of distributed DBMS.
2. explain the design of distributed databases.
3. understand distributed query processing in distributed databases.
4. comprehend distributed concurrency control and transaction processing mechanisms.
5. Recognize causes for database failures and different types of recovery techniques.

Text Books:

Reference Books:

1. Distributed Databases - Principles and Systems; Stefano Ceri; Giuseppe Pelagatti; Tata McGraw Hill; 1985.
Course Objective: To study architecture and capabilities of modern GPUs and learn programming techniques for the GPU such as CUDA programming model.

Introduction: Heterogeneous Parallel Computing, Architecture of a Modern GPU, Speeding Up Real Applications, Parallel Programming Languages and Models.


Introduction to Data Parallelism and CUDA C: Data Parallelism, CUDA Program Structure, A Vector Addition Kernel, Device Global Memory and Data Transfer, Kernel Functions and Threading.


CUDA Memories: Importance of Memory Access Efficiency, CUDA Device Memory Types, A Tiled Matrix – À Matrix Multiplication Kernel, Memory as a Limiting Factor to Parallelism.

An Introduction to OpenCL: Data Parallelism Model, Device Architecture, Kernel Functions, Device Management and Kernel Launch, Electrostatic Potential Map in OpenCL.

Parallel Programming with OpenACC: OpenACC Versus CUDA C, Execution Model, Memory Model, Basic OpenACC Programs, Parallel Construct, Loop Construct, Kernels Construct, Data Management, Asynchronous Computation and Data Transfer.

Laboratory work: Practice programs using CUDA, OpenCL and OpenACC.

Course Learning Outcomes (CLO):
On completion of this course, the students will be able to:
1. Define terminology commonly used in parallel computing, such as efficiency and speedup.
2. Describe common GPU architectures and programming models.
3. Implement efficient algorithms for common application kernels, such as matrix multiplication.
4. Given a problem, develop an efficient parallel algorithm to solve it.
5. Given a problem, implement an efficient and correct code to solve it, analyze its performance, and give convincing written and oral presentations explaining your achievements.
**Text Books:**

**Reference Books:**
Course objective: This is an advanced Post graduate course on quantum computation. Students will able to learn different quantum algorithms and how quantum computers solve problems faster than classical computer.

Introduction to Quantum Computation: Quantum bits, Bloch sphere representation of a qubit, multiple qubits, basics of quantum mechanics, Measurements in bases other than computational basis, quantum gates, Hilbert spaces, Dirac's notation, Entanglement, EPR paradox, Bell's inequality, teleportation, Postulates of quantum mechanics, super dense coding.

Quantum Circuits: single qubit gates, multiple qubit gates, design of quantum circuits, quantum parallelism, Quantum circuits, universal gates, Postulates of QM, Density matrices.


Quantum Information and Modern Quantum Cryptography: RSA Cryptosystem, Comparison between classical and quantum information theory, Bell states, Quantum teleportation, Quantum Cryptography, no cloning theorem, Classical period finding problem, Shor's factoring algorithm, order finding and periodicity, Shor's factoring and discrete logarithm, hidden sub-groups Phase estimation and Kitaev's factoring algorithm, Grover's quantum search algorithm, Optimality of Grover's quantum search algorithm.

Classical Information: Shannon's source coding theorem (1), Shannon's source coding theorem (2), Shannon's channel coding theorem, Basics of coding - linear codes.

Quantum information theory: basics, Graph states and codes, Quantum error correction, fault-tolerant computation.

Laboratory work: To implement Quantum algorithm in any quantum programming language/quantum simulator.

Text Books:
2. Pittenger A. O., An Introduction to Quantum Computing Algorithms
**Recommended Books:**


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**Course Learning Outcomes (CLOs):** On completion of this course, students will be able to

<table>
<thead>
<tr>
<th>CLO1</th>
<th>Knowledge of Performance gain by quantum algorithms over classical algorithms</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO2</td>
<td>Comprehend the basic concepts for designing quantum algorithms.</td>
</tr>
<tr>
<td>CLO3</td>
<td>Acquire the knowledge of Shor’s algorithm, Grover’s algorithm and comparison with the classical algorithms.</td>
</tr>
<tr>
<td>CLO4</td>
<td>Illustrate the concepts of Quantum Error Correction codes.</td>
</tr>
</tbody>
</table>
**Course Objective:** To learn the foundations of Human Computer Interaction. Be familiar with the design technologies for individuals and persons with disabilities. Be aware of mobile HCI. Learn the guidelines for user interface.


**Models and Theories:** Cognitive models – Socio-Organizational issues and stake holder requirements – Communication and collaboration models – Hypertext, Multimedia and WWW.


**Recommended Books**


**COURSE LEARNING OUTCOMES (CLOs)**

<table>
<thead>
<tr>
<th>CLO</th>
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</tr>
</thead>
<tbody>
<tr>
<td>CLO1</td>
<td>To develop good design for human machine interaction system.</td>
</tr>
<tr>
<td>CLO2</td>
<td>Analyze the user’s need in interaction system</td>
</tr>
<tr>
<td>CLO3</td>
<td>To design new interaction model to satisfy all types of customers</td>
</tr>
<tr>
<td>CLO4</td>
<td>Evaluate the usability and effectiveness of various products</td>
</tr>
<tr>
<td>CLO5</td>
<td>To know how to apply interaction techniques for systems</td>
</tr>
</tbody>
</table>
Course Objectives: This course is designed to help the student obtain research skills which includes a thorough survey of a particular domain, finding a research problem and presenting a methodology to resolve the problem; with adequate experimental results to strengthen the contribution. The students are also given an exposure where they learn to write research papers and presenting the work in the conferences. Students are also supposed to learn about communicating the impact of their work by different tools which includes video, poster and presentation.

Course Learning Outcomes (CLOs)

<table>
<thead>
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<th>CLO</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO1</td>
<td>Design and implementation of identified research problem or industrial projects.</td>
</tr>
<tr>
<td>CLO2</td>
<td>Develop acumen for higher education and research.</td>
</tr>
<tr>
<td>CLO3</td>
<td>Write technical reports and publish the research work in referred journals, national and international conferences of repute.</td>
</tr>
<tr>
<td>CLO4</td>
<td>Foresee how their current and future work will influence/impact the economy, society and the environment.</td>
</tr>
</tbody>
</table>

Evaluation Scheme:

- Subject matter of Presentation
- Literature Review
- Discussion of Results and Inferences drawn
- Presentation Structuring
- Response to Questions
- Usefulness/Contribution to the profession
- Overall Perception
- Reflective Diary
- Publication
- Poster
- Video Presentation